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FISHERIES EXHIBITION LITERATURE.

VOLUME VI.

CONFERENCES—PART III.

FISH DISEASES.

THE CULTURE OF SALMONIDÆ AND THE ACCLIMATIZATION OF FISH.

THE HERRING FISHERIES OF SCOTLAND.

MACKEREL AND PILCHARD FISHERIES.

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THE ARTIFICIAL CULTURE OF LOBSTERS.

CRUSTACEANS.

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CONFERENCES—PART III.

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FISH DISEASES

BY

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H.M. INSPECTOR OF SALMON FISHERIES FOR ENGLAND AND WALES.

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CONFERENCE ON TUESDAY, JULY 3, 1883.

The MARQUIS OF HAMILTON in the Chair.

FISH DISEASES.

THE title of the present paper is, I am sorry to say, far too large for its contents, for I propose to speak, not of fish diseases in general, but of that particular malady which attacks freshwater fishes, occasionally assumes the dimensions of a very formidable epidemic, and, in one of its forms, the so-called "Salmon disease," is too well known.

At the first onset of this disease, small whitish patches make their appearance on the skin of the fish. The smooth integument of the top of the head, or of the end of the snout, is a very usual locality, but the adipose fin, and the axillæ of the paired fins are also among the first parts to be affected. If there is an abraded or wounded surface, the disease is pretty sure to attack it, but the invasion of the malady is in nowise dependent upon the pre-existence of an injury. In severe cases, the mischief rapidly extends, until sometimes almost the whole body is covered with an ashen grey coat, which completely hides the scales. On brushing off the crust, however, the scales are usually found undisturbed. In the scaleless parts of the skin, sloughing soon sets in, and deep burrowing sores are formed. On the head, the cranial bones may be

exposed, and the fins are eaten away, and become ragged Very often one or both gill-covers become partially glued down to the shoulder, and the gill-openings obstructed, but I have never yet been able to meet with any sign of disease on the gills themselves. This is contrary to common belief, but I can only say that such is my experience. On the other hand, the disease frequently invades the cavity of the mouth, and often more or less destroys the membranous veil which lies behind the teeth, and plays a curious part in respiration. Thus, although, so far as I have been able to observe, the respiratory organs are not directly attacked, the performance of the respiratory function may be very seriously obstructed.

If the mucous membrane lining the mouth be reckoned with the integument, of which it really is a part, it may be said that the affection under discussion is strictly a cutaneous disease, comparable to ringworm among men. However badly a fish may have been diseased, there is no trace of the affection in the abdominal cavity or in any of the viscera, and the muscles and deep-seated bones appear healthy. Some say that the liver is enlarged and soft, but I have seen the liver quite healthy in very severe cases.

The fish appear to suffer considerable irritation from the disease; but how far this is a primary symptom, and how far it results from the entanglement of multitudes of minute grains of sand in the fluffy coat of the diseased skin, is uncertain. Badly diseased fish in aquaria, the water of which contains no suspended particles of sand, do not show signs of any particular irritation.

The mortality among salmon, sea trout, and freshwater trout caused by this disease is very considerable. In the last five years from 2000 to 4000 diseased fish have been taken out of the Tweed, and a like number out of the

Eden every year. As many as 600 diseased salmon were taken out of the Lune, which is but a small river, last year.

The course of the epidemic has been very remarkable. It began to attract attention in the River Eden in 1877; shortly afterwards it appeared in the Tweed, and it has remained ever since in great but variable intensity in those and adjacent rivers. On the east coast, a few cases have appeared in the Coquet, but none have been noticed in the Wear. Among fresh-run salmon it is almost unknown on the Tyne, though it commonly appears on kelts and on dace. But it has never taken an epidemic character in this river nor in the Tees. In the Yorkshire Esk fifty diseased fish were taken out in 1882, but there has been no serious epidemic. Two or three diseased salmon were taken out of the Ure last season, but southward of this I have no information of any disease in the rivers of the east coast.

It may be said, then, that there has been practically no epidemic outbreak in the eastern rivers south of the Tweed. On the west coast of England the state of affairs is totally different. Since 1879, the disease in its epidemic form has made its appearance more and more to the south, until last season it broke out in the Usk and in the Wye.

These facts are very remarkable and very important. For if, as I believe to be the case, the morbid affection the skin is wholly extirpated when the salmon descend to the sea, it is not possible that the disease should be propagated from one river to another by the immigration of fish from an infected into a healthy river. It is quite possible that the fungus which, as we shall see, is the cause of the disease, might be transferred from an infected to a healthy river by birds, but the evidence in the Tyne and in the Usk is conclusive that the disease has long existed

to a slight extent in these rivers, so that the theory of transportation is superfluous.

Again, the facts are not favourable to the supposition that either pollution or overcrowding has much to do with the matter. The Clerk of the Kent, Bela, Winster, Leven, and Duddon district reports this year that, in the River Duddon, there is no obstruction between the sea and its source, and that it is perfectly free from pollution. The river is to a great extent unpreserved, and there has been no overcrowding. The disease was not noticed till last year, 1881–2, when the watchers removed about forty fish. The Leven is an outlet of Lake Windermere. The only possible source of pollution is the sewage of the little town of Bowness, which falls into the great body of water of the lake, and may be disregarded. Disease was unknown in the Leven until the last season, when it suddenly became the most infected river of the district.

A very competent authority, Mr. Berrington, Chairman of the Usk Board, informs me that the disease has always been known to occur occasionally, especially in late kelts—rarely in fresh-run fish; sometimes in dace, trout, and young salmon. In 1881, however, it was carefully looked for, but no trace of it could be found. Nevertheless, in January and February, 1882, it was unusually prevalent in spawning salmon. In the end of March and in April, when the river contains the smallest number of salmon, a violent epidemic broke out among the trout, and lasted through May and June.

The salmon ran up the river early this year; and, in April, numerous diseased clean fish were observed. Between the first week of July and the end of October, the disease entirely disappeared; but, in November, a violent outbreak occurred, trout and salmon, spawned and unspawned,

dying in large numbers. This epidemic lasted until the middle of May of this year. It then began to diminish; salmon could be watched recovering from the disease, and by the beginning of June it had almost disappeared, although the river was very low. In the previous year freshes had no effect in diminishing the disease.

I attach great weight to these careful and precise observations, and I shall have something to say about their bearing by-and-by. They prove conclusively that, even while the fish remain in fresh water, diseased salmon may completely recover, and they would leave no doubt in my mind that the epidemic has no necessary connection either with pollution or with overcrowding, even if this point had not been settled already. Mr. Byers, formerly surveyor in the Government service in British Columbia, told the Commissioners who inquired into the salmon disease in 1880, that he was on the Harrison River, one of the tributaries of the Fraser, in that dependency in 1861, and that he there saw thousands of diseased salmon. The disease has also been observed in the Castries rivers in Siberia. Yet neither in British Columbia nor in Siberia can the rivers be much troubled with pollution from high farming or industrial occupations. It is true that Mr. Byers attributes the disease to overstocking, but this is a mere guess; and it is negatived by the facts adduced before the same Commissioners by Sir James Maitland, who kept 12,000 Lochleven trout, varying in weight from half a pound to five pounds, from November to March 1878-9, in three ponds, each about 300 feet long, 45 feet wide, and 6 to 13 feet deep, without loss of more than 1 per 1000. Another very singular fact which has been brought to light by observation, though it certainly sounds paradoxical, is that even a violent epidemic of disease, continued for several years, does not

diminish the productiveness of a river. The Tweed has suffered as severely as any river during the last five years, and yet the catch of salmon in 1882 (8,808) was more than double what it was in 1879 (3,472).

I have been favoured this morning by Messrs. Forbes, Stuart & Co., of Lower Thames Street, with the following returns, which show that, disease notwithstanding, the supply of salmon from the rivers of the United Kingdom to London, in the month of June just past, was far in excess of that in the same months in the five preceding years.

ARRIVAL OF SALMON IN LONDON IN JUNE FOR THE LAST 5 YEARS IN BOXES.

	1879.	1880.	1881.	1882.	1883.
Scotch	1,541	1,847	2,544	3,605	6,643
Irish	1,553	1,864	1,995	1,243	3,073
English	409	756	524	848	760
Berwick	132	182	197	198	245
Dutch	113	9	45	7	39
Swedish	26	122	..	52	28
Norwegian	131	175	178	80	124
Total	3,905	4,955	5,483	6,033	10,912

Such are the most important phenomena presented by salmon disease in this country. Naturally its rise and progress have excited considerable alarm, and the usual swarm of empirics have propounded their dogmas about the causes and their specifics for the cure of the disease.

Nothing is more curious than the readiness of people who dare not undertake to mend a meat-jack because they know nothing about machinery, to give decided opinions

about the causes and the method of dealing with natural occurrences, the mechanism of which is infinitely more complicated than that of the culinary apparatus—while their ignorance of even the elements of the problem is absolute.

Surely it does not want any science, but only a little common sense, to see that the first step in a case of this kind is to find out the exact nature and causes of the phenomena over which we wish to exert a control. The foundations of such knowledge in respect of the salmon disease were laid by the late Mr. Stirling, in a series of papers which appeared in 1878 and 1879, and I have been trying for the last two years to raise the superstructure, which, however, is, as yet, by no means complete.

If the fluffy whitish coat which is so characteristic of the diseased skin—and is sometimes tenacious enough to be stripped off in flakes like wet paper—is examined microscopically, it is seen to consist chiefly of a tangled mass of fine filaments, on an average about $\frac{1}{2000}$th of an inch in diameter, which are at once recognisable as the stems (or *hyphæ* as they are technically termed) of a fungus (*Saprolegnia ferax*), similar to those which are known as "moulds," and which commonly grow upon, and obtain their nourishment from, decaying organic bodies. The so-called "blue mould" (*Penicillium glaucum*), which attacks all sorts of dead organic bodies from cheese and jam to old shoes, is a familiar example of these plants, which, however troublesome to housewives, play a very important part in the economy of nature as scavengers, by whose agency dead and decomposing organic bodies are cleared away. All the fungi which thus prey on dead animals and vegetables are known as *Saprophytes*, a term which may be pretty nearly paraphrased by "rot-plants."

But there is a large number of these moulds which are not saprophytes, but parasites; that is to say, they attack living animals and plants, and in many cases destroy them with great rapidity. The silk-worm culture is sometimes ruined by the so-called "muscardine" disease, caused by a mould, the *Botrytis bassiana*, which enters the body of the silk-worm and destroys its substance.

In some autumns, our common domestic flies are destroyed in prodigious numbers by another curious mould, the *Empusa muscæ*. Even mankind are not free from the attacks of fungi, as in the ringworm of children's skins. And as to plants, multitudes of destructive epidemics of which the smut of wheat and the potato disease are the most notorious, are produced by parasitic fungi of various kinds.

As a general rule, fungi are either saprophytes or parasites—that is to say, they live habitually either on dead or living organic bodies.

Now the *Saprolegnia ferax* which, as we have seen, forms the cottony covering of the diseased salmon skin, is habitually a saprophyte, especially found on dead insects; and when it was first discovered to be a constant concomitant of the salmon disease, there was very good reason for suspecting that it might be a saprophyte, preying on the dead tissues of the skin destroyed by a precedent affection, and not a parasite, the presence of which was the true cause of the destruction of the tissues.

When I addressed myself to the study of the disease two years ago, therefore, I endeavoured in the first place to obtain conclusive evidence on these two points. 1. Is the saprolegnia of the salmon the cause or only the concomitant of the disease? Is it the real enemy or only a camp-follower? 2. If the *Saprolegnia* of the salmon disease is a true para-

site, is it identical with the *Saprolegnia* already well known as a saprophyte?

It was for this purpose that I went to Bettws-y-Coed, in the winter of 1881, in order to study, on the fresh fish, the nature of the epidemic of salmon disease which had broken out in the Conway; and I soon obtained the evidence I sought, for by examining the margins of moderate-sized fresh patches on the heads of salmon, it was not difficult to demonstrate that the patch of fungus constantly extends at the periphery by sending out fresh hyphæ into the healthy epidermis, which it breaks up and destroys; at the same time, it drives into the subjacent vascular true skin hyphæ which play the part of rootlets; these, ramifying in the superficial layer of the true skin, give rise to sloughing. If a single strawberry-plant is set in the middle of a bed, it will send out runners in all directions, and these will strike root into the soil wherever they go until the whole bed is covered. The *Saprolegnia* patch grows in a somewhat analogous fashion, but its "runners" and "roots" destroy the living tissues in which they are lodged.

These observations left no doubt in my mind that the *Saprolegnia* is the cause and not a mere accompaniment of the salmon disease—that the latter is in fact what pathologists term a *mycosis*. And with respect to the other point, namely, the identity of the parasitic with the saprophytic *Saprolegnia*, I found it easy enough to obtain equally conclusive evidence.

If the salmon *Saprolegnia* was the same as that which commonly grows on dead insects, it is obvious that one ought to be able to sow dead insects with it and raise a crop of the fungus on them; and in fact nothing is easier than to do this. Fill a clean tumbler three parts full of clean spring water, and provide it with a loose paper cover; then

catch two or three common house flies, kill them by squeezing them gently without breaking the tough skin in which the body of the fly is enveloped, and rub them softly once or twice over a patch of diseased skin. Drop the flies into the tumbler, and they will float at the top on account of the large quantity of air which their bodies contain.

If the bodies of the flies are examined at this time with a good magnifying glass, nothing will be seen but a few threads representing the hyphæ of the saprolegnia, which have been entangled by their legs and bodies.

By way of a check experiment it is advisable to put two or three flies caught at the same time, and treated in the same way, into a tumbler of the same water, but taking care that they are not brought into contact with the diseased skin. In this tumbler, covered as before, the bodies of the flies may remain for weeks, and gradually decay without showing any trace of fungus. Sometimes, however, *Empusa*, and sometimes, *Penicillium* or *Mucor* may make their appearance. In the first case, the germs of the *Empusa* were certainly in the body of the fly when it was killed. In the second, they were very likely on it, but may have been imported from without. In no instance that has ever come under my observation, has *Saprolegnia* made its appearance in flies treated in this way. This is singular, considering that it is often stated that *Saprolegnia* appears regularly on flies thus treated; but I imagine that this is the case only when pond or river water is used.

The phenomena presented by the flies which have been brought into contact with the diseased salmon skin are very different. In about four-and-twenty or, at most, six-and-thirty hours, that part of the body of the flies which is in contact with the water presents a more or less

extensive coating of fine, short, white hyphæ, set so close together that they look like a close-cropped turf. These filamentous hyphæ grow with great rapidity, and spread more and more widely. Their increasing weight gradually drags the fly's body down, until it becomes completely submerged, and at length sinks to the bottom, invested by a white ball formed by the hyphæ, which radiate on all sides from its body.

Microscopic examination now shows that these hyphæ perforate the tough cuticle of the fly, and ramify in the interior of its body, destroying and appropriating the tissues. On their outer free ends, on the other hand, a large number of the hyphæ are terminated by a sort of fruit (*sporangium*) in which the minute bodies (*zoospores*) which play the part of seeds or germs are formed, and from which they are eventually discharged. The comparison of the characters of the sporangia and spores with those of *Saprolegnia ferax* will leave no doubt that the fungus thus transmitted from the fish to the fly is of that species.

In order to complete the chain of proof, it was necessary to give the disease to fish by infecting them with *Saprolegnia* from the insect. As I had very little time to devote to the experiments requisite for this purpose, I requested my friend Mr. George Murray, of the Botanical Department of the British Museum, to join with me in making them. Our first attempts yielded negative results, but, on the 2nd of March, 1883, Mr. Murray rubbed a saprolegnized fly on the left flanks of two healthy dace, at a spot about the middle of the length of the body.

"On the 5th of March," Mr. Murray reports, "each of these fish had a small tuft of what was afterwards found to be *Saprolegnia ferax* growing on the region of inoculation, and, by the 10th of March, it had grown into a large patch."

One of these fish escaped. "The other died on the 16th of March, its body being nearly covered with a luxuriant growth of *Saprolegnia ferax*." Two other fish similarly infected died, the one in ten days and the other in fourteen days. This, so far as I know, is the first direct evidence that the *Saprolegnia* of the salmon disease is capable of being transmitted from dead insects to living fish of other kinds.

Combining these observations with those made on the epidemic among carp by Unger in 1844, and with those of Stirling on the fish in the Ightham ponds, I begin to doubt whether any other fungus than *Saprolegnia* attacks fishes. A distinction is often drawn between the "aquarium fungus" and *Saprolegnia*. But within a few days of the opening of this Exhibition, the trout and char in the freshwater tanks were largely attacked by "aquarium fungus," and I took the opportunity of subjecting fresh specimens to careful examination. I found it to be all *Saprolegnia ferax*, and I could cultivate it on flies just as well as the salmon *Saprolegnia*. As yet, I have met with no satisfactory evidence that the integument of fishes is attacked by anything but *Saprolegnia*.

The *Saprolegnia* is essentially a freshwater organism, which dies as soon as an infected fish reaches salt water. As, however, it is only the exposed part of the fungus which comes into contact with the sea water, it was possible that the hyphæ, which are embedded in the true skin, might retain their vitality during the sea life of the fish, and make their appearance at the surface on its return to fresh water. And, when I made my first report on the disease, I thought it possible that the key to the mystery of the appearance of the disease in fish just returned from the sea might lie here.

But this does not appear to be the case. Mr. List, the Chief Constable of Berwick, has been good enough, at my request, to repeat some experiments which he had formerly made upon the effect of confining diseased salmon and sea trout in coops in the tideway of the estuary of the Tweed at Berwick; and, in June 1882, he sent me two sea-trout which had got completely well under these circumstances, though signs of the situation of the patches of disease remained. Careful examination of the skin in these regions by means of sections prepared for the microscope, revealed no trace of the fungus; so that it would seem that the parasite is completely rooted out by the sea water.

In a river which remains year after year the seat of epidemic salmon disease, therefore, *Saprolegnia* must be permanently resident there, in some shape or other; and the fish which ascend are infected by this stationary store of the fungus.

In the experiments which have been described, the fungus has been brought into direct contact with the fly or the fish to be infected; but this is not at all necessary. In a full-grown specimen of the fungus, the great majority of the hyphæ end in sporangia, and one of these may contain a hundred or more minute zoospores. These, when ripe, are ejected from the sporangium, and each is propelled by a pair of cilia through the water. By these means, and by the currents in the water, these zoospores may be drifted a long way, and if any one of them reaches a fish, it may germinate, penetrate its skin, and give rise to the disease.

The quantity of zoospores which may be produced from a mass of *Saprolegnia* no larger than that which covers an ordinary fly, is prodigious, and a few diseased salmon

might thoroughly infect the waters of a considerable stream.

But it is possible that no trace of *Saprolegnia* may be present either on living or dead organic bodies in a mass of fresh water, and that no *Saprolegnia* may be imported from without; and that, nevertheless, after a time, these bodies may be attacked by the fungus. This arises from the circumstance that *Saprolegnia ferax*, like other *Saprolegniæ*, has two modes of reproduction, the one sexless, by zoospores, such as have been described, the other sexual, by *oospores*, which answer to the seeds of ordinary plants. Reproduction by zoospores is the ordinary and constant process, that by oospores takes place with less regularity. I have never seen an oospore upon *Saprolegnia* growing on salmon, and there are some sources of difficulty in the identification of these bodies which lead me to entertain a doubt whether any other observer has done so. Mr. Murray, however, has found them abundantly on *Saprolegnia* growing on dace. *Saprolegnia* may be cultivated on flies for many months without the appearance of oospores, and then, in a solitary specimen, they may present themselves in great numbers.

These oospores are spherical bodies provided with a thick coat. Once formed, they pass into a quiescent condition, in which they may remain for many months. Sooner or later, however, they awake to new activity, and their contents either break up into zoospores which are set free and roam about until they reach an appropriate nidus, or grow directly into a *Saprolegnia*. Thus it is possible that the *Saprolegnia* in a pond or stream, having given rise to oospores which fall to the bottom and remain quiescent, may die away and leave no apparent trace of its existence, and yet, months afterwards, the oospores may germinate,

and in a few days give rise to an abundant crop of the fungus.

It is not only possible, but probable, that there are yet other forms totally different from the ordinary *Saprolegnia*, under which the mould may continue its existence. The recent investigations of Brefeld on the torula condition of many fungi (*Ustilago, Tilletia*), known hitherto only as parasites on plants, are very significant in connection with this question.

Permit me now to sum up, in a few propositions, the present state of our knowledge respecting the salmon disease:—

1. The sole cause of the disease is the fungus *Saprolegnia ferax*, which burrows into and destroys the skin of the fish.

2. This fungus habitually lives on dead organic matter, and exists only in fresh water.

3. The *Saprolegnia* is propagated by zoospores, oospores, and possibly also in other ways. The zoospores and the oospores give rise either to the saprophyte *Saprolegnia*, which lives at the expense of dead organic matter, or to the parasite *Saprolegnia*, which lives at the expense of living freshwater fishes.

4. The zoospores of the *Saprolegnia*, grown on fish, attack dead flies, and the zoospores of the *Saprolegnia*, grown on flies, attack living fish.

5. It follows, therefore, that the existence of the cause of salmon disease, or, to speak more generally, of the integumentary mycosis of freshwater fishes, is independent of the existence of fishes; and consequently that the extirpation of all the diseased fish in a river does not involve the extirpation of the cause of the disease in that river.

6. There is reason to believe that the *Saprolegnia* exists

in its saprophytic form in most fresh waters, and that it attacks the fish of most rivers occasionally. In other words, the mycosis of freshwater fishes is a widespread sporadic disease.

7. That which it is now desirable to ascertain, is the nature of the influences under which the sporadic disease suddenly assumes an epidemic character.

On this point we have very little light at present, for although there is some reason for thinking that deficient oxygenation, whether produced by overcrowding or otherwise, may favour the development of the disease, and though it is possible that some kinds of pollutions may favour it, yet the disease sometimes becomes epidemic under conditions in which these two predisposing causes are excluded; and it does not always appear when they are present.

8. Epidemics subside spontaneously, though the fish remain in fresh water.

9. The productiveness of a salmon river is not necessarily interfered with by even a violent epidemic.

The last three propositions indicate the moral of my paper—which is to make sure that you know what you are about before meddling with the salmon disease. Until the causes which convert the sporadic into the epidemic disease are known, all interference is mere groping in the dark; and when they are known, it will be a great question whether the preventive measures adopted are worth their cost.

Fishery doctors at the present day remind me of human doctors in my youth—they were always for doing something. I remember one of my teachers laid down the notable maxim, "when you are in doubt, play a trump," and I should think that those of us who have followed his advice, in the last forty years, must have largely added to the

bills of mortality. Our fishery doctors are of the same mind as my friend. They are (or at any rate ought to be) very much in doubt, and yet they continually want to play trumps in the shape of stringent regulations and restrictions. If I might tender a piece of advice, I would say—don't.

DISCUSSION.

Mr. FOLLETT asked why it was the diseased fish rose to the surface of the water, he referred especially to gold fish in artificial ponds.

Professor HUXLEY said there was probably an increase in the amount of air in the air-bladder, and very likely in the viscera also produced by incipient putrefaction.

Dr. SPENCER COBBOLD, having paid some attention to parasites for a great many years past, had come there hoping that Professor Huxley would open up the whole subject, though contemplating its vast extent, he felt that even he would find a difficulty in compassing it. This not having been done, he would say a few words on the parallelism between the *rôle* played by external and internal fungi which might throw a little light on the general subject. It was found on examination that certain fishes were covered with Saprolegnia, and when they were dissected they found no trace of internal parasites. In such cases where death had supervened it was evidently due to the presence of Saprolegnia alone, but in other cases a number of internal parasites were also found; and when they took into consideration the fact that the *rôle of* the internal parasite was so similar, with regard to the irritation it created to the external, the only difference being that the irritation set up by the internal parasites was in the muscles and viscera, it was impossible for any logical

mind to deduce any other conclusion than this, that the internal parasites were sometimes associated with the external in the production of disease and death. On the other hand there were some instances where no external parasites were found, but there were hundreds of thousands of small parasites of the entozoa character, which brought about the same fatal issue. In illustration he might mention that a few years ago one particular kind of parasite, which he he had shown to the Prince of Wales and Prince Napoleon the night before, killed hundreds and thousands, and, as one French author said, hundreds of thousands, of coarse fish. Professor Huxley had shown in a most interesting manner that the germs of Saprolegnia might be propagated by other bearers than the salmon itself; and here again he would point out that there was a parallelism with the internal parasites, they being conveyed by bearers or intermediate hosts. The adult parasite required a change of hosts, passing from small insects to the fish. That was the case with one which was very common in the perch, and other coarse fish, and the higher parasites or the larger ones, the *cestodes*, were also propagated through the means of intermediary bearers. It might interest the audience if he were to state a curious fact in connection with parasites in fish as he might not have another opportunity of doing so, owing to his numerous engagements. Whilst showing a specimen of a large ligula, so common in fresh-water fish, to Prince Napoleon, he reminded him that they were what were called in Italy "Maccaroni piato," and were constantly eaten there as a delicacy, being supposed to be fleshy growths inside of fish. Fortunately it might be hoped that this particular parasite would be destroyed with even the very slight cooking, and even if not cooked, there was no reason to suppose that the ligula would be transformed

into a higher form of parasite in the human body, although there was a form found in these fish which was transformed into the well known *bothriocephalus latus* which was well known in Russia and sometimes in Ireland.

Mr. MARBER wished to draw Professor Huxley's attention to a case which had come under his notice this year in connection with a small river in Scotland. This year there were a number of fresh-run salmon in the river in the month of March which had never been known before by the oldest inhabitant. After they came there were a great number of diseased fish found with this fungus, that disease never having been known to his knowledge in the river before. He should like to ask if any reason could be given why these fresh-run salmon, which never before appeared in the river so early, had come there and brought this disease immediately after.

Professor HUXLEY said the salmon were quite innocent of bringing the disease there; there was no doubt they caught it in the river.

Mr. MARBER said the river was prolific in salmon, but they were always very light. They were never known to arrive so early before, and these were not native salmon of the river.

Professor HONEYMAN (Canadian Commissioner) said the subject of parasites had been brought to his attention for some time past, and not long ago, when preparing the collections on the other side of the Atlantic for the Exhibition, he one day bought from a countrywoman a very fine trout, which he thought would be suitable to exhibit, and took it with him to the Museum. A friend who took great interest in subjects of the kind—one of the foremost investigators in fish anatomy—informed him that he had just discovered that some fish he had bought were full of para-

sites, and that he had informed the health officer of the circumstance, and the sale of the fish had been stopped. On examination he found that the one he had purchased was similarly affected. The people who came in from the country to sell these fish felt annoyed at the sale being stopped, and very naturally so, but the health officer went fully into the subject, and the result was that a formidable collection of parasites was exhibited; the consequence was that many people got exceedingly alarmed, and consulted him about it. He told them if they went inquiring into everything they ate they would never eat anything at all. The best way was not to take alarm at the results of scientific investigation, but to go on eating, and not ask any questions. He must say he had never heard of anyone the worse for eating fish, even if they did contain parasites. They often heard of all the ills that flesh was heir to, but, judging from what they had now heard, and from the appearance of a specimen in a glass jar on the platform, there were many ills which fish were heirs to as well, and there were certainly a most formidable collection of these parasites shown by Dr. Cobbold.

Mr. MACKENZIE wished to ask Professor Huxley if he had taken into consideration the question of preventing the distribution of *ova* from infected rivers. It seemed to him that was a case where, perhaps, the heroic remedy would be the only proper one until light was thrown on the modes in which this disease was propagated.

Mr. SIGGINS said that during last April he spent a few weeks at Ramsgate, and in conversation with the fishermen there he remarked that the mackerel were unusually large, but that they were the worst in flavour he had ever met with; their reply was that the fish were out of season, and no fisherman would ever think of eating mackerel at that

time of year, but if he looked under the skin before they were cooked he would find a large collection of parasites. It occurred to him that, probably, the fish which were diseased were the fish out of season. There was a season for all things, a season for the flowering of plants, and a season of rest, and without the natural rest there would be no bloom. He believed the fault of our country was to rely on fish every day in the year from whatever source it might come. There was a time for all things. Game was not shot except at the proper season, for if they did they might at once repeal the game laws, and by the end of the year there would not be a single bird left. In the same way there should be preservation of fish. Oysters were now at an almost prohibitive price in consequence of the overfishing of the beds, owing to the greater demand, and the facilities offered by railway and steamboat carriage.

Professor HUXLEY, in reply to Mr. Mackenzie, could not say he thought the distribution of ova from diseased fish was of the smallest consequence. If the ova were attacked by the disease, they would be immediately distinguished and weeded out if the most ordinary precautions were taken, whilst healthy ova had no power whatever to transmit disease.

Mr. WILMOT said it afforded him much pleasure to be able to say a word or two on this very destructive agency, which was causing so much injury to the rivers of Great Britain, *Saprolegnia ferax*. It had been his misfortune to have differed with the learned Professor on the protection of the fisheries of the world; but on this occasion he was glad to offer him his best thanks for the interesting lecture he had given on this most important disease. He felt that in this case science was doing most useful work, and hoped that by further investigation, a cure for

this terrible disease would be arrived at. He believed, too, that it was only within a few years past that it had prevailed very largely in the rivers of Britain; he had been engaged in connection with fisheries for many years past, and sixteen years ago this disease was known within the small confines of the house where he was engaged in fish breeding, and his opinion, though he might be wrong, was that it was only brought about by a pollution of the water, and the increased heat occasioned by the country being cleared of its forests. This tended to bring down in the river immense quantities of infinitessimal vegetable spores, which floating down came in contact with the diseased fish, or fish which had been injured by the fishermen and others, and produced Saprolegnia. In catching these fish in the stream, in the province of Ontario, for the purpose of cultivation, it was found that many fish died from the following cause. The fish had to be caught by hand in the stream, and strict instructions were given to the men always to catch them by the tail, because, in catching them by the head the gills were always injured, and that necessarily proved fatal. The men went into the river, waded up the stream, and caught the fish on their beds at night, and at other times, in the day time, when they had their heads underneath the logs which abounded in the stream. The fishermen then carried the fish twenty or thirty rods to the house; but they invariably found, after the first or second year, that many of these fish died, the reason being that round the tail where the men had caught the fish, this peculiar sort of fungoid growth appeared, which spread until the fish was killed. This was in 1867 or 1868, before he knew anything of *Saprolegnia*. In order to avoid it they introduced common gloves, which had been used ever since, because they were found less likely to

injure the fish. Sometimes, also, a man from hurrying or carelessness, would grab a fish across the back, leaving finger marks upon it, and in a few days after, they invariably found three or four stripes of fungoid growth appearing, and the fish invariably died. He, therefore, came to the conclusion that this fungoid growth was the result of infinitessimal spores coming down the stream, which produced this growth on the bruised portions of the fish, and the fish could not shake it off because they were generally in a prostrate and lean condition after spawning. This disease did not prevail generally in the United States, or in any other country in its natural state. Nearly all the rivers and streams, when the country was first inhabited, were pure and limpid, the waters were cold, and these immense numbers of spores did not float down the rivers; but as countries became cleared, and the volume of water reduced by absorption and evaporation, and by the superheating of the water by the sun's rays, more of these spores were produced, and when the fish were injured, as they now were by fishermen catching them, and by passing through nets, and in getting injured as they came up into the rivers, they were more liable to be attacked, and so the disease was produced. He believed there was no possibility of overcoming it until they could somehow change the waters up which the fish migrated. Another mode would be by improving the protection of those fish which could escape up the river. He might dilate on this subject, and would assure the Conference that unless some greater efforts were made to protect the fish in every possible way, they must expect them to be decimated in the end. He believed the practical remedy was to preserve fish by judicious laws, and prevent men destroying them, and also to prevent the polluted matter being allowed to flow into the stream.

Professor HUXLEY said Mr. Wilmot's remarks were very interesting and important; but there was one observation which it was necessary to make in regard to them. There was extremely good evidence that the salmon disease not only occurred, but devastated the fish in British Columbia and Northern Asia, where he need not say there was no possibility either of over-fishing or pollution.

The Marquis of EXETER then proposed a vote of thanks to Professor Huxley, and in doing so wished to refer to one or two points in connection with this fungus. He found in his own tanks and ponds, whenever they were exposed very much to the sun and intense light, the fungus had appeared more or less; he also found that in breeding salmon from some eggs sent from Canada he succeeded in raising the salmon, and they lived for about six weeks, and were apparently very healthy; but all at once this fungus began to show upon them, and, though they changed the water, nothing seemed to do them any good. He should say that the water in which he bred the fish at Burleigh was very highly impregnated with lime, so much so that kitchen boilers got choked in a very short time; and whenever they attempted to breed these salmon from ova taken from Scotland and elsewhere, after they had lived apparently well for a certain number of weeks, they invariably died of this disease. In a pond close by where there was hardly any shelter from the light, the fungus generally appeared, but it was not so where there was more shade. Latterly, however, since his present pisciculturist, Mr. Silk, had been with him, when the fungus began to show upon the fish they gave them a salt-water bath, which cured them. Some time ago he gave some black bass to the Aquarium, which did well for some time, and then the fungus appeared upon them; but as Mr. Silk was coming to London, he called there and gave them a salt bath which cured the

disease, and they lived for some time afterwards; so that this fungus was quite destroyed by the administration of this bath of salt water. Of course these fish were put under the doctor directly there was the slightest sign of this dangerous disease upon them, and since then they had hardly ever lost a fish. The black bass also which came over from America in the fresh-water tanks became very seedy, and he thought that they should lose a great many, but he got some salt water out of the sea, kept them in it two days, and they all recovered and were doing well wherever they had been sent.

Sir JAMES MAITLAND seconded the motion. He had hoped that Professor Huxley would have gone very widely into the question of the diseases of fish, for they were by no means confined to the *Saprolegnia ferax*. Although perhaps of late it had occupied a large portion of the scientific research which had been bestowed on the Salmonidæ, it must be remembered that in old days when they had not the same restriction and protection they had now, although the disease was occasionally mentioned in books as the murrain among salmon, it was uncertain how far it extended. In those days the waters were frequented by otters, and there was a good deal of poaching, and he doubted if many fish that got high up the rivers ever returned into the sea, and that might account for the contradictory results obtained on the Tweed, which showed that exactly four years after the disease broke out in a virulent form the number of fish caught was much larger than before. It might be that the death of those old fish, which in descending the rivers would probably swallow a number of smolts, enabled the river to recoup itself by the growth of the young fish; and in the case of a shorter river the results might be different. In the Tweed there was a long stretch of dead water

between Kelso Bridge and the sea, where kelts congregated, and would very likely eat smolts nine inches long. He had just heard that this disease had reached the Don, but it was very unusual for it to break out in an almost epidemic form at this time of the year. With regard to parasites, he found that although many fish bore them they seemed to occasion very little inconvenience unless the fish were out of condition at the time. A fish exhausted or spawning was nearly always infested with parasites, and would very readily fall a victim to them.

The motion have been carried unanimously,

Prof. HUXLEY in reply said he knew nothing as to the effect of sun light, but should imagine that the elevation of temperature must play a considerable part in inducing the condition of fish which allowed it to take the disease. He had been much interested in what Lord EXETER had said respecting the limey character of the water of his district, because when this Exhibition was opened all the trout and some other fresh water fish in the new tanks with one consent began to show disease, and, that they still showed it, might be seen by the specimen on the platform taken from one of those tanks. In fact he had an opportunity of studying in the Aquarium the fungus on one of these fish, and satisfying himself that it was exactly the same thing as the salmon disease. That interested him very much in consequence of a remark made by Mr. Saville Kent who had paid considerable attention to these subjects. He said to him, as they walked round the Aquarium, that that it was a matter of course, because the water had not been allowed to run sufficiently long through the newly cemented reservoirs and tanks, and whenever that was the case the *Saprolegnia* was almost certain to make its appearance. That opened up to his mind a very interesting

chapter of inquiry, though up to the present he had not been able to make any experiments in regard to it. It was very possible that any superabundance of lime in the caustic state might have a very considerable effect in bringing about the development of the disease. In the first place fungi of all kinds were extremely sensitive to small degrees of acidity and alkalinity of water, and secondly the condition of acidity and alkalinity was extremely likely, however small its extent might be, to have a very definite effect on the epidermis of the fish. This, therefore, suggested a line of investigation, which was likely to prove extremely fruitful. As to the use of salt, he believed that was an absolute remedy, and there seemed to be a consensus of opinion to that effect. Some experiments carried out by the Conservators of the Tweed showed that fish, even in an advanced stage of the disease, when confined in cribs in tidal waters, if they did not die of the confinement, got well of the disease. Although there was one doubtful case on record of disease showing itself on fish in salt water, unfortunately the evidence that the disease was caused by *Saprolegnia* was wanting; and up to the present he had never been able to see any sufficient ground for believing that *Saprolegnia* could appear on any fish in salt water. Finally he would say one word about fish parasites. The fuss made about the parasites of fish was really very extraordinary. The lower animals, and fish especially, were not at all particular about parasites. Parasites were regularly and constantly found in particular parts of their organisms, and might rather be considered sharers of their repast than anything else, simply taking toll of whatever came in their direction. In most cases, there there was not the least evidence that these parasites had any effect on the welfare of the fish. He remembered that two

or three years ago great complaints reached him from Bristol, where a large number of very fine mackerel were brought in, and the town was in an uproar, because it was said that these fish were full of parasites, and they would destroy all the good people of Bristol who ate them. Any-one who paid attention to fish must be aware that certain nematoid parasites were extremely common, but the fish were none the worse for them, and as to people catching them, in the first place they were not the same kind as those which infest man, and, secondly the fish were going to be cooked; and although the idea was not pleasant, cooked parasites *per se* were not any worse than cooked fish. As to the prevalence of parasites having anything to do with fish not being eaten at the right time of year, he did not think anyone familiar with fish would be likely to entertain that idea.

Mr. FELL WOODS then proposed a vote of thanks to the Marquis of Hamilton for his conduct in the chair, as well as for the great earnestness and energy with which he had devoted himself to the work of the Exhibition. With regard to the question of parasites, he had observed that the cockle at a certain stage abounded with a little parasite, which seemed to leave it in a perfectly healthy condition, and in no way interfered with it as an article of food if cooked, but there was this disadvantage that it did seem to interfere entirely with the fertility of the fish. The same thing occurred in the oyster in the Mediterranean.

Professor HONEYMAN seconded the vote of thanks, which was carried unanimously.

The CHAIRMAN, in responding, said they had had a most edifying discussion in connection with the various diseases of fishes. They had had the opinion of two very eminent gentlemen from Canada, and he was certain that Englishmen

had derived much advantage from the instruction they had brought. They were all aware of the go-ahead ways of the race on the other side of the Atlantic, but of all the go-ahead statements he had ever listened to, that of Professor Honeyman, who recommended people to eat fish when they were diseased, seemed the most remarkable. There had been many discussions in that hall, but in his opinion none so instructing and interesting as that which had taken place to-day, and he felt that the public were much indebted to Professor Huxley for the time and attention he had devoted to this important subject. He had confined himself to the salmon disease, and probably he was quite right in so doing, the salmon in our rivers being the means of giving such a vast amount of food to all classes of the population, that it would be a lamentable thing if, owing to the ravages of any kind of disease, its supply should be in any way limited. Two points which he had brought out seemed to him of especial importance, viz., that though the exterior of the fish might show signs of the disease, the inside did not appear to be affected; and, secondly, that the epidemic could not be traced either to pollution or overcrowding of the rivers. In conclusion he would express a hope that as the result of Professor Huxley's labours, not only scientific, but practical, men interested in fisheries would devote further time and energy to study the causes of these diseases, and ultimately discover a remedy by which the diseases might be entirely eradicated.

THE

CULTURE OF SALMONIDAE

AND THE

ACCLIMATIZATION OF FISH.

BY

SIR JAMES RAMSAY GIBSON MAITLAND, BART.

CONTENTS.

CONFERENCE ON THURSDAY, JUNE 21, 1883.

THE Chair was taken at 11 o'clock by the MARQUIS OF EXETER, who, after referring to the Inaugural Address by Professor Huxley, and the Paper by H.R.H. the Duke of Edinburgh, said the Conference would to-day be invited to give their attention to another branch of the great question of our fisheries, one which, though nearer home, and perhaps less exciting—for it involved no danger to either life or limb—was of great importance, and to many persons formed a most interesting pursuit. He alluded to the attempts which had been made to increase the value of our fisheries by artificial breeding and by importation; and they were much favoured in having the subject opened with a Paper by Sir James G. Maitland, Bart., who had devoted a great deal of time and energy to fish culture.

Sir James G. Maitland then read his paper as follows:

THE CULTURE OF SALMONIDAE AND THE ACCLIMATIZATION OF FRESH-WATER FISH.

The culture of Salmonidae properly understood embraces not only their artificial propagation, but also the production of their food; the regulation of their ascent to their spawning beds and of their descent to their feeding grounds; the manner of their capture and their rapid and economic con-

veyance to market; just as much as the culture of corn is understood to mean not merely the sowing, but every step from the preparation of the seed bed to the marketing of the harvest.

The acclimatization of freshwater fish I will consider with special reference to the Salmonidae, and attempt to foreshadow the results of the importation of some of the best known foreign species.

ARTIFICIAL PROPAGATION.

The artificial propagation of the Salmonidae is still in its infancy, but the bearing it has on their cultivation in the future is so important, I propose to commence this paper with a short description of the process, and explanation of the principles which are involved in the selection of a site for, and in the erection of, a hatchery.

THE HATCHERY.

The most important requisite for the hatching house is pure water; it is indeed to a hatchery what coal is to a steam-engine, all hatching apparatus of whatever kind being merely mechanical devices for extracting and transferring from it the greatest amount of energy to the ova.

WATER.

Water in its natural state is frequently unsuitable for the earlier processes in fish culture. It is subject to great variations of temperature; it is rendered muddy by rain, and occasionally it is impregnated with lime or mineral to a fatal extent. Water in Great Britain, taken from a natural river even but a few miles from its source, is generally so contaminated with pollutions resulting from

civilization as to be unsuitable not only for the delicate ova and fry, but also for mature Salmonidae.

River water, however, if unpolluted and not overcharged with sediment, can generally by an expensive system of settling tanks be rendered safe for hatching purposes, and the alevins from ova incubated in river water in Scotland commencing to feed at a late period in the spring obtain much natural sustenance. Filtered water cannot be used with good results in a hatchery. The best filters deprive water of all animal life, while inferior filters cannot be run for six months continuously without great risk either of their fouling or passing an uncertain supply, especially where they have to contend with leaves and heavy frosts. Spring water is more equitable in temperature, generally free from sediment, and not liable to rapid fluctuation in the supply, but as the ova hatch out earlier the fry are entirely dependent for some months on artificial food. Taking everything into consideration, spring water should be used for the permanent supply to the hatching house, care being taken that it contains nothing in solution deleterious to the embryo, and of this, experience is the only safe guide; but it is very important that a supply of river water for summer use be also laid on, otherwise the fry must be removed from the trays four or five weeks after they commence feeding.

Temperature.

The average temperature of the water during the period of incubation fixes the length of that period, which varies in Scotland from 70 to 150 days. I formerly considered 41° Fah. as the best average temperature, Salmon eggs hatching in 97 days, while fungus does not grow readily, byssus taking from three to four days to generate to a

dangerous extent on the dead ovum, and the saprolegonei hardly appearing at all, at least on the charred surfaces of the hatching boxes; but I now find by using a larger flow of water through the trays, and by increasing the flow during the latter stages of incubation, that with a temperature of 45° Fah., fully 99 per cent. of Loch Leven Trout ova can be hatched into healthy well-formed alevins, and very nearly as good results with the eggs of the Salmo Salar, the difference being probably due to the difficulty of obtaining perfect impregnation in the case of ova taken from wild fish.

Spring water seldom varies more than a few degrees even in very cold weather, and where it is used the duration of the hatching period can be accurately approximated, which is often a great convenience.

At Howietoun in the winter of 1878–79, river water fell within a degree of freezing, and remained there for three months, so that Trout ova took 105 days from being spawned to the first appearance of red blood, which marks the middle of the period of incubation.

The quantity of water required in the process of incubation depends partly on the number of eggs, partly on the temperature of the water, and partly on the hatching apparatus used, but as I have hitherto only attained the very best results by the grille and tray system in the incubation of the eggs of Salmon and Trout, I will consider the water supply solely with reference to it, merely remarking that the quantity used in this system is greater than in any other; the result of eight seasons' experience has been in favour of the supply of not less than ten gallons a minute for every hundred thousand Lochleven Trout ova; about a third more for Salmon ova, and only a fourth of the quantity for the same number of Fontinalis

ova. A very much smaller supply will suffice during the earlier stages of incubation, but it is absolutely necessary to be able at any moment to command a sufficient supply in case of emergencies, such as are frequently occasioned by frost or by unusually warm weather.

Next only in importance to the water itself are the connections between the source and the hatchery. In making the connection with the spring it is safest to follow the spring a few feet below ground and fill in the hole with large stones. Where many small springs require to be tapped, a collecting well should be dug, lined with rough masonry, into which all the springs can be led; the connection to the hatchery from this well should be made by leading a glazed spigot and faucit pipe to the point nearest the hatchery, which will give sufficient pressure to feed the whole house by gravitation; here another small well, also lined with masonry, must be constructed, and from it a metal pipe (as fireclay will not stand much pressure) led into the hatchery, this arrangement keeps all the pipes underground, where they are safe.

The connection with the stream to bring in river water is not so simple, the greatest care must be exercised to secure a constant supply, and the difficulty of forming a permanent and perfectly safe connection is always very great. Leaves and débris are in some streams very troublesome, and ice at the beginning of a frost is a serious source of danger, floating against the screen or grating, and freezing to it. I once lost 300,000 Lochleven Trout ova from this cause. The winter had been unusually severe, the thermometer for several weeks never rose above 25° Fah., but at the beginning of February a thaw set in, and by the 1st of March every trace of ice had disappeared. The stream which fed the Fishery was in spate, and one of my hatching

houses is situated within the works, the water supply being obtained from a 20-ft. plank pond, used in winter as a settling tank, and whose feeder is supplied by a 10-in. pipe from the main inlet works. These in their turn are supplied by a sluice in a coffer-dam, and guarded by a screen placed nearly parallel to the surface, formed of perforated zinc in summer and of wooden slats $\frac{3}{4}$ inch apart in winter. The wooden frame had been removed on the 3rd of March, when the temperature fell suddenly to 12° Fah., and the thin ice floating down the surface of the stream clogged the perforated zinc screen, and froze into a solid mass, entirely stopping the supply of the works; the water in the hatching trays unfortunately had been lowered two days before to increase the current so as to keep the eggs cleaner during the spate. The water fell in the boxes sufficiently to partially expose the eggs, these just showing the coloured globules which precede the formation of the red blood, and a thin film of ice formed on all the eggs. A few hours afterwards the screen was relieved, and the eggs thawed out by a gentle current of water. For a week no bad symptoms were visible, then several thousand turned white; in a month it was evident that, although few more eggs had actually died, most of them had made no further progress, and the few which showed a distinctly formed embryo only proved how thorough had been the work of destruction: the ice had squeezed all vitality out of my baby Trout.

The stoppage of water by the screen being clogged with thin ice is frequently an invisible danger. It cannot occur when the stream is frozen entirely over, as the thin ice only travels on the surface, and when it comes against the screen is held there by the suction of the water in the same way in which a leaf is (this, of course, must not be confounded with

the screen freezing up from insufficiency of water, which only occurs at a more advanced period of the frost); the stoppage, moreover, is temporary, for as soon as the temperature rises, or the stream freezes entirely across, the cause is removed, and the water soon clears the passage for itself, but in this lies the very essence of the danger, namely, that the water may have been off the works for a few hours, and the eggs exposed to frost, and in the morning everything seems as usual, and the cause of the eggs dying, perhaps a week afterwards, entirely unsuspected. It is not advisable to place any hake or screen guarding the inlet perpendicular to the water, as leaves, &c., will collect in great quantities, and although fir branches laid in front generally prevent the water being entirely cut off, the amount of cleaning and watching is considerable, and a certain risk will always exist.

A leaf screen made of perforated zinc laid nearly parallel with the surface of the water is probably the safest way of making a connection with an open river; if properly placed, any débris collecting on the screen, so soon as it begins to reduce the flow, is washed off by the upper current, and the supply after having passed through the zinc screen can be led into a small collecting well, and thence piped to the Hatching-house.

The Hatchery itself should be substantially built on sound foundations, brick and concrete being probably the best materials to use; ventilation, light, and protection from frost are the principal objects in construction; and above all things the drains must be sufficient and rat-proof. Keeping these points in view, the situation of the Hatchery should be governed by the water supply. The house also should be as large as possible, as very much better work can be done in a few central establishments than in many

small ones. Eggs both fresh and eyed are so easily and safely transported that distance from the spawning streams is of far less consequence than proximity to a first-class railway station, from which the distribution of the fry can be readily effected.

The extreme importance of properly constructed and efficiently controlled Hatcheries must be my excuse for having dwelt so long on this portion in the paper, especially as a very prevalent and to many a very pleasant idea is that every watershed in the country should teem with small Hatching-houses, and that the water should be stocked with the improperly developed eccentricities so freely produced by dirt, ignorance, and overcrowding.

APPARATUS.

The apparatus employed in hatching Salmonidæ must necessarily vary with the species, temperature of water in hatching, and the character of the waters it is proposed to stock. The principal object is not to incubate the largest number of eggs in a given space, but to so incubate the ova that at some future period—for instance, twelve months after laying down the ova—the largest number of healthy fish may result; and I say this advisedly, for it is quite possible to hatch a very large percentage of the ova, and yet a very small percentage of the fry survive the first few weeks after they commence feeding. With a low temperature, and where the ova have to be sent away either as eyed ova, or the fry to be turned out before the conclusion of the yolk sac period, a very much larger number of Salmon and Trout eggs can be incubated per gallon of water per minute without any apparent loss than is possible in this country with a high temperature of water and with fry under constant observation for months after they commence feeding.

At Howietoun I use boxes, each of which will rear 15,000 Lochleven Trout fry for five or six months after hatching, and this without any appreciable loss, but I do not care to lay down more than 20,000 eggs on the grilles in each box, the size of the egg being 35,000 to the gallon. I find that if the eggs are laid down any thicker than this there is a decided difference in the vitality of the alevins and feeding powers of the fry.

I will now consider the Hatchery as a factor in the cultivation of migratory Salmonidæ, restricting myself for the present to those species placed by Dr. Günther in the group Salmones either with a wide geographical range, as Salar, Trutta, and Cambracus, or limited to Great Britain and Ireland, as Brachypoma and Gallivensis, merely pointing out that while touching on the general conditions common to the increase of the above named species, the extermination of the Bull Trout on the Tweed and the Sea Trout on the Forth forms a very serious point to discuss in treating of the culture of the Salmon, and that the best results can only be obtained by the careful protection and artificial production of the species best suited to each particular district. The objects here are to increase Salmones whose pastures are in the sea, and whose nurseries are in the rivers.

The size of the river has no fixed relation to the number and weight of fish caught in its estuary and contiguous seaboard, and if a very large number of smolts were annually turned in immediately above the tidal waters the stock of Salmones would be increased by a proportion of the number turned in, fixed only by the conditions of food and of natural enemies in the estuary and adjoining sea. I do not mean to say for an instant that all the fish reaching maturity would return or attempt to return to the mouth of the river in which they were liberated as smolts, but I think

that the evidence tends to show that most of them would do so. The question at this point resolves itself into a matter of pounds, shillings, and pence. Salmon smolts of two years old can now be raised at less than sixpence apiece, and Salmon in the estuary on their return are probably worth on an average five shillings each; rent and the expense of nets, wages, and rates probably add another five shillings, of course if there was a much increased take the proportion to each fish would be less and all the fish that return to the estuary are not caught, but it will be sufficient for our purpose if we assume that a Salmon on his road to destruction is worth while still free five shillings two years after it has been liberated as a smolt; if, therefore, 10 per cent. of the smolts turned in are caught two years afterwards no profit will result, for the increase would only equal the first cost, and the interest on the outlay would be nil.

The old idea in this country was to turn out young fish big enough (and big enough does not necessarily mean sufficiently educated) to take care of themselves. The results from the Stormontfield experiment at first, when everything was new and in working order, were sufficiently marked, but they have not been permanent, and if pisciculture had achieved no more, Salmon culture, in this country at least, would be an interesting exotic, with magnificent results in some cases, far oftener with none; but fortunately it is not necessary to depend on two-year-old smolts for the future increase of our Salmon fisheries. Mr. Spencer Baird, who I am glad to see so ably represented at this Exhibition, in a letter to the Commission of Fisheries of the Dominion of Canada, refers to the magnificent increase of Salmon in California, an increase in five years from five to fifteen million pound weight in one river, an expenditure of merely two million Salmon fry per annum, which in this country

would entail less than a thousand a year after making a full allowance for all expenses. But stocking with fry or with smolts is but a small portion of the great question; parts of some of our Salmon rivers are too fouled by pollution to rear fry after they are liberated; it is only by adapting the means to the end that Salmon culture can reach the highest degree of success. In many parts of the country where the pollution is only moderate, we can meet it by taking advantage of the pure water above or by turning smolts in directly above the tidal waters, but I am certain the surest remedy for pollution is to make pure water pay. It is easier to shake an industry to its foundation than to put something better in its place, and if, through fish culture, pure streams and more plentiful food would displace the black sewers of our midlands without the intervention of harassing legislation, fish culturists will not have laboured in vain.

The next important point in Salmon culture is a consideration of the mode of stocking. The watershed must first be carefully surveyed, and the quantity of natural feeding for young fry, yearlings, and smolts estimated. Where clear spring water can be obtained close to gravelly shallows suitable for alevins, the most economical and efficacious manner of stocking is to cut narrow ditches just above flood water mark, fill in with gravel, and sew down eyed ova a few days from hatching, cover over with branches, and leave alone.

Where no springs exist young fry a few weeks after commencing to feed should be turned into the gravelly ripples, but where the stream is too sluggish or too large to be safe for fry, yearling fish can be turned in in spring as soon as the kelts are out of the water, but smolts should only be used immediately above the tidal water.

The temperature, hardness of water, earthy particles in

suspension, rainfall, &c., must be carefully studied in connection with turning in the young salmon, but with a little experience ultimate success is assured.

The Hatchery can supply eyed ova for the redds and fry for the shallows, and ponds should be constructed near the Hatching-house for yearlings, but where it is necessary to stock with smolts ponds for the purpose must be constructed near the head of the estuary, as the carriage of two-year-old samlets is neither easy nor economical. The time that intervenes between the smolt just entering the tidal water and its first return towards the river varies considerably on the east coast of Scotland; two summers may sometimes intervene, and we must be careful not to assume that all fish return or attempt to return in the grilse stage, for I have found in the case of the Lochleven Trout only a small proportion spawn in the corresponding state.

But whatever the time is we know that his growth is most rapid, and his sea food must be studied before much further advance can be made in Salmon culture; garvies and young herring probably form a great portion of his food, but whatever it be his paths in the sea are as well marked, and to some fishermen, alas, as well known, as in the river.

Trammels in the sea are successfully dropped by east coast fishing boats on their way out and lifted on their return. The food of Salmon at sea may possibly be influenced by the modes of fishing. Boats year by year go farther north and farther to sea for their Herrings; the fishing grounds are slowly but surely receding from the shore. It is too early yet to foreshadow the results, it may be that food inshore grows more plentiful now that the Herrings are further out, or it may be that the Herrings are further out because the inshore food has decreased, it may be, and to a certain extent it must be, a matter of changing

currents and temperatures; but what I wish to impress in this paper is that the sea food of the migratory Salmones forms a very necessary preliminary study to the great question of Salmon culture.

A diagram expressing the art of Salmon culture would contain no broad, hard, rectangular lines, no vivid colouring easy to be understood, but flowing curves traced by the ever varying intensity of the now few now many circumstances whose combination constitute the problem of the migratory Salmones. Temperature and food are here, as with the non-migratory species, the principal factors. The modes of capture and obstructions in rivers also weigh heavily against the increase of Salmon. But when one of our watersheds is sufficiently artificially stocked so that the advantages of the process are brought clearly and directly before the public an alteration in the modes of legal capture will assuredly follow.

Of obstructions in the river it is difficult to treat; many upper proprietors prefer good Trout fishing to the pleasure of dragging about a few kelts in spring, and it cannot be too strongly impressed that Trout are most destructive to Salmon spawn, and that Salmon in their turn are after spawning most destructive to Trout.

I am aware it is very commonly held that Salmon do not feed in fresh water, probably because in common with all large-ovaed Salmonidæ the ovaries for from two to eight weeks completely fill the cavity of the abdomen, and should the fish yield to hunger during this time the freshly swallowed food causes the immediate extrusion of the ova.

If Salmon never fed in fresh water a well-mended kelt would be a superfluous expression in the parlance of fishermen.

The deduction as to kelts in certain parts of the rivers is obvious.

Obstructions in the river will interfere little with young fish artificially bred descending to the sea, although they are often fatal to the ascent of spawning fish. Returning to the artificial propagation of salmon, the selection of breeders is very important, eggs from young fish being far smaller in size and the fry hatched from them more delicate than is the case with ova spawned from mature breeders. I think it therefore necessary that the Salmon should be caught and selected so soon as the rod fishing closes, as by selecting the best hen fish the future stock of the water will be much improved.

The non-migratory Salmones in this country are classed by Doctor Günther under the following species—S. Fario: Ferox: Gilleroo Nigri-pinnis; Orcadensis and Levenensis, but probably with the exception of the S. Levenensis, which more nearly approaches a marine form, these are all more or less permanent varieties of Fario; and their fry, at least those produced under artificial conditions, are more easily reared than the fry of the migratory species. Their cultivation may be said to consist in the selection of the oldest females for breeding purposes, in the artificial incubation of the ova and the rearing of the fry; beyond this their culture resolves itself into a question of habitat and food, of habitat by choosing the species or variety best suited to the ends in view, and of food, for it is only by increasing the food supply in the water that the heaviest weight per acre and the most delicate quality of the flesh can be produced. The cultivation of the food supply in fresh water is effected by the reduction of coarse consumers of food who come in competition with the Salmones, by the cultivation, introduction, and acclimatization of fish whose value as food for Salmones is greater than the value of the sustenance they themselves derive from the water, as, for instance, the

Char of Loch Rannoch, who subsist almost entirely on the daphnæ pulix. The smelt, and some of the white fish also, may be the link in the chain which will bind the land-locked salmon to our northern lakes, and prove a very disturbing weight in the scales on the side of the upper proprietors on waters now tenanted by the migratory Salmonidae. I have only just commenced the construction of a botanical pond to enable me to study water plants as herbage for molluscæ, shelter for grammari, and the natural production of myriads of ontromostrica. On the sea-shore of the Western Highlands if the kelp be not regularly cut, or in other words rudely cultivated, for cutting is most assuredly a process in cultivation, the whelks and bukies decrease on account of the want of the young tender shoots of seaweed, and the fishing in the neighbourhood is sensibly diminished.

From this it is easy to understand what a great future may be opened out by the systematic culture of water plants in our inland waters.

Food limits the culture of non-migratory Salmonidae, therefore our study must be where to grow it, how to grow it, when to grow it, and what to grow. In lakes some shoal swimming fish is essential to the growth of the large species of non-migrating Salmonidae. Since the Char have disappeared from Lochleven in the first quarter of the present century, the ten pound Trout in that loch have passed into the realms of romance.

Acclimatization here steps in ; either the freshwater Smelt of America or our own Osmerus eperlanus, which I have successfully hatched and am now rearing in fresh water, if introduced into a Highland loch, for instance, Loch Tay, would enable it to carry a very heavy crop of some of the larger inland species, for instance, the landlocked Salmon of Loch Werner in Sweden, or the S. Sebago of America ;

but we must not conclude that the acclimatisation of every species is in all cases desirable, for if the Black Bass were introduced into the Tay, and the Pike Perch allowed to sport wherever he listed, even were the sport with the new comers at all commensurate with the highly-coloured descriptions which we have read, it will hardly compensate for a troutless river, and a salmonless estuary. There may be parts of the country where the Pike Perch would form a desirable addition to the local fauna, but I cannot conceive the Black Bass, who is only at his best in waters essentially fitted for Salmonidae, to be other than a most dangerous intruder. The Colorado beetle boasts, I believe, of a special Act of Parliament, and I do think the introduction of strange and dangerous species of fish should only be attempted under State control.

The S. Sebago, should he retain in this country his non-migratory instincts, would probably be a splendid fish for the Thames, and if used in the upper parts of the Severn would introduce a new and important element in the question of the respective rights of upper and lower proprietors. It is not for the public good that this should be done, for this fish would probably be able to hold the spawning grounds from all comers, and a rapid decrease of the migratory species would be the result, and if it be urged that a lake species would not localize itself to the upper portions of our larger rivers, still if crossed with a British variety, such as S. Levenensis, it in all probability would do so. The acclimatization of the Corregoni, of which there are many species, all of which can be easily transported as alevins is, in my opinion, only to be considered as a factor in the production of food for more valuable Salmonidæ. If we had the great American lakes, no doubt the large white fish of Canada would, if introduced, form a valuable article

of popular food, but our space in this island is too confined to enable us to deal with other than the best we can have, and I doubt, except in a few solitary cases, if any of the Corregoni fall under this head.

The introduction of Golden Tench and the varieties of Carp are not considered in this paper, as the acclimatization of fishes has been treated merely in relation to Salmonidae.

DISCUSSION.

Mr. WILMOT (Commissioner for Canada) said he rose with great pleasure to move a vote of thanks to Sir James Maitland for the very lucid and instructive Paper he had read, for he felt satisfied that much benefit would be derived from it. He was a deep lover of the science of fish culture, believing it to be one of the means by which the population of the earth hereafter would derive much benefit in the way of food and wealth. It was well known that the waters of almost every country which had been largely inhabited had become very scarce of fish, but this result was brought about by the greed and avarice of mankind almost entirely, not in consequence of the predatory habits of other fish which frequented the same waters. In any new country an abundance of fish was to be found in the rivers and waters, showing that the balance of nature was evidently correct; that though fish fed on fish, they did not exterminate one another; but the moment man stepped in with his engines of destruction, the fish were reduced to such an extent that this great International Exhibition had been established for the purpose of devising means whereby this description of food could be increased. He regretted to find that, to some extent,

there was a difference of opinion with regard to the means to be adopted to this end, but, for his part, he advocated the protection of fish in every possible way, as well as of assistance to those engaged in artificial production. In Canada this subject was of very great importance. It was now some years ago since artificial culture was introduced by himself, with the recognition of the Government, and now they stood second to no other country with regard to it. The number of Salmon they turned out annually was not exceeded by any other country in the world. During the last two years from thirty-five to forty millions of Salmonidae had been turned into the waters of Canada through the artificial process, and, though there were no doubt sceptics and others who were inimical to the science of fish culture, he thought that could only arise from ignorance of the benefits to be derived from it. At first sight it seemed extraordinary that fish could be produced by artificial means; but it was a most simple process when understood. Fish were so prolific, that man with a little ingenuity could produce from them far more than nature could herself, because it was a well-known fact that large quantities of the eggs of the fish family were destroyed by other species. This was the ordained law; it was intended that fish should live on fish, because if all the eggs of fish were permitted to hatch out, there would be no room in the waters for them. Consequently, nature had provided wisely that fish should live on one another, and this being the case, large numbers of ova must be consumed. Under artificial culture, however, where the egg was protected from its enemies, a larger percentage could be brought to maturity than by the natural process. Hence, if it could be shown that 75 per cent. of the eggs could produce living fish, the system ought to be encouraged by all intelligent

people. Sir James Maitland had gone into the matter in a most lucid and instructive manner, and there was no doubt that when the Paper was disseminated it would do a vast amount of good. The only difficulty that he saw was, that it did not appear to go hand in hand with the ideas of some scientific gentlemen, who maintained that protection was not necessary to some of our fish. He contended, however, that if an intelligent country considered fish culture of service at all, it should also adopt every possible mode of protecting the fish. It would be no use for a pisciculturist to trouble himself to reproduce fish in great numbers if the intelligence and legislation of the country did not protect that which had been produced, and if every one were allowed to fish without any control. It seemed to him, therefore, that it behoved all who were interested in this matter to join in every possible measure to enhance the production of fish, either by natural or artificial means, and also to protect the fish afterwards. Nearly every civilized country possessed laws for the purpose of protecting fish; and when some gentlemen came forward and said that fish could not be exterminated, the consequence must be that all these protective laws were a mistake, and that every one should be allowed to kill and eat as he pleased. He maintained, on the other hand, that it was the duty of the legislature of every intelligent country to suppress intemperance of all kinds, not only in the matter of liquids, but in killing fish; and to pass judicious laws for the benefit of mankind. If any law were more judicious than another, it was that the waters should be protected from the inordinate destruction of man, in order that fish might be produced in larger numbers, both as a luxury for the rich and for the benefit of the poor. He felt that he was treading on somewhat

delicate ground in giving expression to these sentiments; but as this was the first opportunity he had had, he felt it his duty to express publicly the strong conviction which he entertained on this subject.

Professor HUXLEY begged leave to second the vote of thanks which had been so well moved by his friend Mr. Wilmot. Unfortunately, he had not had an opportunity of seeing Sir James Maitland's establishment at Howietown, but he had frequently been favoured by reading and hearing what he had done, and thus had the means of knowing not only the nature of his operations, but what was to his mind the singularly precise and accurate scientific spirit which he had brought to his work, and it was the secret of the very remarkable success he has obtained. In this matter, as in all biological questions, the secret of success lay in attention to minute details, and that was really the moral of the Paper. You must, in the first place, be able to comprehend precisely—which very few people did—the exceeding complexity of natural conditions, and then you must know how to carry into practice all the precautions necessary to meet the variation in those conditions. He could not recommend anyone who was endeavouring to acquaint himself with natural history to take up a more useful and valuable study than that of the manner in which Sir James Maitland had carried out his operations with regard to fish culture. He dwelt upon this point the more because, since the time—some forty years ago—when M. Coste first popularised the notion of fish culture, the idea became prevalent that you only had to carry out artificial impregnation, or the collection of spat in the case of Oysters, and the thing was done. He need not say what disappointment those who first experimented in the matter of Oyster culture were destined to

undergo; that was a matter recorded not only in the minds but the pockets of a large number of persons. The same considerations applied to all forms of fish culture, and unless those who undertook it were prepared to work at it with that happy combination of science and practice which was exemplified in the case of Sir James Maitland, disappointment would await their efforts, as it had those of many persons who had attempted the same process. For himself, he did not take very rosy views of the value of protection pure and simple for sea fisheries, but perhaps he was all the more inclined to attach especial value to thoroughly well considered and scientific fish culture. He was inclined to think that it was in this direction we must look, and not to measures of inefficient protection, for the ultimate preservation of our fisheries. This was not the time to discuss the point, but he gathered from Mr. Wilmot's remarks that there was some extremely wicked person who had been saying that protection was of no use in Salmon fisheries; that people should be allowed to destroy anything and everything they liked; but anybody who heard the remarks he had ventured to offer at the first Conference would be aware that he, at any rate, was not one of those wicked persons. No one had insisted more strenuously than he had done on the absolute necessity for the most careful protection for those sea fisheries in which protection could be shown to be efficient, and if any one were prepared to show that measures of protection as efficient as those which were adopted in the Salmon fisheries, and which must be enforced unless the Salmon fisheries were to be destroyed, would be equally efficient in the case of any of the sea fisheries, by all means let them be adopted, and no one would be a stronger advocate for protection than he should be; but, until it was made clear

that the regulations were efficient, that you were really doing something for the fishery, and not burdening the fishermen with useless and vexatious regulations, it would be better to leave the question of protecting sea fisheries alone.

Mr. BRADY (Inspector of Irish Fisheries) said he might say a word on the question of the protection of Salmon fisheries, as compared with the protection of sea fisheries. He belonged to the sister country, and they had had a great deal of experience with regard to the protection of both sea fisheries and Salmon fisheries. There were very valuable fisheries in Ireland, and a series of Acts of Parliament had been passed for their protection, though previously to 1848 there was no machinery for putting them in force. The Act of 1848, however, gave the machinery, and imposed licence duties on all engines used for the capture of Salmon; the amount of revenue thus derived being over £10,000 per annum, and the effect had been that within his own official experience the Salmon fisheries had increased from about £2,000 a year to nearly £6,000. With regard to sea fisheries, although he was as great an advocate as Mr. Wilmot could be for the protection of any industry where it was required, he quite agreed with Professor Huxley that if there was any doubt whatever about the effectiveness of legislation, he should not hamper fishermen by restrictions which might be perfectly useless. The Act of 1842 gave power to the Commissioners in Ireland to impose restrictions on sea fisheries as well as Salmon fisheries, and certain restrictions were placed in certain bays on certain modes of fishing, particularly trawling. In one bay the restrictions were introduced in 1843, and were continued till 1862. At that time a change in the Government took place, new ideas came in, and an

inquiry was held as to the advantages derived from these restrictive bye-laws in this particular bay, the result of which was that the late Sir Richard Griffith, as Chairman of the Commission, resolved to put an end to these restrictions, and this was done much against the wish of those who opposed trawling. The effect had been that all classes of fishing in that bay had greatly improved. There was another bay where the same restrictions against trawling were imposed in the same year, and had remained to this day, and at the present time the fisheries there were more deteriorated than they were fifty years ago, when trawling was first interfered with. It would no doubt be asked, Why did he not repeal that bye-law? Well, he certainly was inclined to repeal it, and invited the trawlers to give evidence on the point; but they did not come forward, and therefore there was no power for the Commissioners to act.

Dr. DAY said he did not think the remarks of Mr. Brady had much to do with the subject in hand, for he could not help thinking he had given opinions in the place of reasons, and statements in the place of facts. Certainly trawling might be going on and fisheries might improve, but who that knew anything about fishing would admit that because you secured a number of fish you must be improving fisheries? Acting on that principle, if you killed all the fish you would be improving the fisheries. He could not see that trawling could by any possibility improve fisheries in a bay, unless it killed certain carnivorous fish; however, this question would come forward at another time, when it could be more fully discussed. With regard to the Paper of Sir James Maitland, he would remark that that gentleman had taken up a position which was assumed by the Government in most foreign countries;

he had, at his own expense, kept hatcheries and fisheries, which in almost every civilized country were carried on by Government officials. If they were told that a person who drew a fish out of the water was entitled to the thanks of the community for adding to the food of the people, how much more was he entitled to gratitude who spent his time and money in increasing the number of young fish, and so augmenting the food supply of the population at large? Another question of some importance was this, Whom had they to thank for the present condition of fisheries? Why those who made such large profits destroying the Salmon by polluting the rivers. If the legislature permitted these things, surely it was bound to give some assistance to fisheries by adding to the supply of young fish, to make up for those that were destroyed. Sir James Maitland was carrying out investigations which no doubt would be of great benefit to fisheries; he was trying experiments on hybridisation of fish. With regard to land-locked Salmon, it might or might not remain in the upper waters of the river if there was no large lake to which it could have access. Also the question arose, if you crossed the Trout and the Salmon, whether the young would be sterile, and if they could not breed, would they develop the propensity of going down to the sea. If the fish remained in the upper waters of upper riparian proprietors, would they have the means of getting a breed of fish which they could keep to some extent to themselves? At present the lower riparian proprietors on some rivers were catching the largest proportion of the Salmon, whilst the upper riparian proprietors were like clucking hens who were hatching eggs and letting the fish down to destruction. With reference to the acclimatization of fish, Sir James Maitland had given a warning which ought to be taken

to heart. There were many who would introduce new kinds of fish to our waters, for three reasons; one, that they were good for sport to our anglers; secondly, that like the Gold Tench, they were pretty; and thirdly, that they were useful. Now he must confess he thought the Black Bass was too rapacious a fish to be introduced. They heard the other day of a wonderful collection of fish in the sea, and if science would only point out any enormous piece of water in which this Black Bass could prey on shoals of fish as large in quantity as the Cod off Lofoten Islands where they were told some 120 million existed in one mile, then the Black Bass might be introduced, but until these localities were found it would be as well to be cautious.

Mr. WILLIS BUND said he knew a gentleman on the Severn who had for some years, at great expense, hatched a large number of fish and turned them into the water. This year, owing to some local jealousies, as soon as ever the fish were turned out, a considerable quantity of lime was put into the water, and the fish were killed. Of course that was an offence which could be dealt with and punished, but there was another kind of offence, glanced at in the Paper, which they were wholly powerless to prevent, and of which they had an instance only lately. A gentleman had spent a large sum in artificially breeding and in bringing a Trout stream to a very high state of efficiency, when a neighbour of his placed in the stream a bucketful of young Pike. Of course he could not more effectually have destroyed the work of years, but he was guilty of no legal offence whatever. He therefore considered the hint given in the Paper was very valuable, that some provision should be made to prevent rapacious fish being introduced into water not suited for them. Every water should be made to produce the best fish it could, and if Salmonidae were

the best fish those waters could produce, they ought to be confined to them; at any rate, if large sums of money were spent, either by private individuals or the public, in introducing new fish and in improving the fisheries of the water, there ought to be some means by which ill-natured persons could be prevented turning in rapacious fish, and thus in a short time undoing the work of years. Either the Local Fisheries Board or the Home Office should have some authority or power to say what fish should be turned into the waters, and he hoped that some regulation of this sort would be one of the useful results which would follow from the Conference.

Professor G. BROWN GOODE (U.S. Commissioner) said said he should be pleased to give a few figures illustrating what fish culture could do. Professor Baird (U.S. Commissioner) informed him that the Sacramento River, California, was, owing to the large number of canneries there, to a large extent depleted of its Salmon; but by the establishment of a hatchery there he had turned out something like sixty-seven millions of eggs or young fry of the Californian Salmon in the past eight or nine years, one-fourth of which were put into the Sacramento River, and it was now much more productive than ever before. On the Clacamass, in Oregon, a similar experiment was tried some years ago with a like result. These experiments had clearly shown that the Salmon industry of the Pacific Coast, which was now producing fish to the value of something like three million dollars a day, was thoroughly under the control of fish culture. He might also take the case of the Connecticut, in the last century, which was one of the most productive rivers; but by the construction of a great dam, 60 miles above its mouth, the Salmon were cut off from the spawning ground, and for very nearly ninety

years not a Salmon was seen. In 1866, or thereabouts, the Commissioners of Connecticut began to plant Salmon in this river, and four years afterwards they began to appear. In the first year 500 fine Salmon, of 15 lbs. to 20 lbs. each, were taken; in the following year almost an equal number. Since that the Commissioners of the States have discontinued Salmon culture in that river, the supply has again fallen off, and the river might now be considered practically deprived of its Salmon again. He simply wished to add a word in confirmation of what Sir James Maitland and Dr. Day had said concerning American Bass. Although he did not like to say anything against a fish which was a countryman of his own, he thought it was a fish which interested only the private individuals who were able and willing to feed him, and were willing to pay any sum for the gratification they found in angling. So far as fish with which public fish culturists should deal, the Black Bass had no claims whatever, unless they put him into the same stream with Pike, and let them fight it out together.

Mr. W. OLDHAM CHAMBERS, seeing Professor Brown Goode on the platform, thought perhaps he would have given the Conference the benefit of his experience with the *Salmo sebago*. A few months ago Professor Baird sent him over fifteen thousand eggs of the land-locked Salmon, in the hope that they would form an important feature in fish breeding in this country, but he said nothing or little about the *Salmo sebago*. He thought there were many rivers in England which were completely cut off from the sea, and if the land-locked Salmon could be introduced into them, or into the Broads of Norfolk, it would be very advantageous.

Professor G. BROWN GOODE remarked that his colleague Mr. Earle might be able to give more definite information

concerning the land-locked Salmon than he could, but at the same time he should like to make up for his detractions of the Black Bass by saying a word or two in favour of the former fish. It was held in high esteem by his countrymen, as might be judged by the fact that the United States Commissioners had for some years carried on a hatching establishment on Grand Lake Stream and the subordinate streams on other lakes in Maine for the propagation of the eggs of this fish. The young fry had been introduced into many smaller streams and lakes in the Northern States. The experiment had not been worked out to the utmost extent yet, but there was every reason to believe that the land-locked Salmon was going to be extremely valuable in the northern lakes, and he saw no reason why it should not be equally valuable in the lakes of Scotland. Mr. Wilmot was equally familiar with this fish, for it might be said to be more abundant in British North America than in the States. It was undoubtedly the same race as the *Salmo salar*. In some instances it had become land-locked by the erection of dams within the memory of man, in other instances it had become land-locked by natural causes before or soon after the settlement of the country, whilst in other instances, again, it was not land-locked by any artificial obstructions, but remained without any obstacle to its visiting the sea save the great distance it would have to traverse. It lived in the head-waters of some of the large rivers. The same might be said, to some extent, of the red-spotted Trout, or Char (*Salmo fontinalis*), which in the northern parts of Canada and Nova Scotia descended to the sea, where it lived during a large part of the year, and was known as the Sea Trout, and was a great favourite of anglers. It inhabited the lower stretches of rivers and streams, and frequently descended into the sea; those

which did get into the sea were considered to be very fine. After passing the limit of Long Island, which was the limit of the distribution of Salmon, the same barrier of warm temperature which seemed to keep the Salmon from going up the large rivers, prevented the red-spotted Trout from descending from the mountains to the sea; and it had really become land-locked by reason of temperature barriers in the southern part of its range, though it extended into the southern spur of the Alleghanies six or eight degrees of latitude farther south than the point at which it was able to descend to the sea. The land-locked Salmon is a most delicious fish, though not quite so large as the *Salmo salar*; it was rarely more than eight or ten pounds in weight, and, on account of its long detention in fresh water and diminution in size, its eggs were considerably smaller than those of sea-running Salmon.

Mr. WILMOT said there was a celebrated American showman who once came to England and took away an animal called Jumbo. The same gentleman in former years exhibited a certain animal at his museum in New York which he advertised as the "What is it?" It seemed to him the same term might be applied to the land-locked Salmon. His impression was that there was no such thing in existence as land-locked Salmon, scientifically or naturally. It was the true *Salmo salar*, which had a different coat and a different shape from the water it lived in, in the same way that the showman he referred to put a coat on the animal he exhibited.

Land-locked Salmon, which he called *Salmo salar*, was a fish which could be obtained by any pisciculturist at his pleasure; all he had to do was to hatch from the egg of the *Salmo salar* a number of little fish, put them into a large body of water from whence they could not reach the

sea, and if they found food congenial to their wants, they would grow and develope into a large fish, slightly changed in colour and scarcely perceptibly in form. Such had been his experience in America and Canada. Lake Ontario was once filled with this fish. When he was a youth he had known thousands killed in one night, and the farmers caught them in such numbers as they entered the streams to deposit their ova, that some of them got enough to buy their farms with. In the stream which ran within a few yards from where he was born and brought up he had killed hundreds and thousands of them on their migration up from their sea, Lake Ontario, into the smaller streams and rivers to deposit their ova, in the same same way as the *Salmo salar* left the ocean and ascended rivers. For want of proper precautions, proper protection and good legislation, this Salmon had almost disappeared from Lake Ontario. At first there were no laws in the country, and consequently every man killed as he pleased, and as the poor creatures came up, they were destroyed right and left. The Indians killed them, and the white Indians killed them still more. To prove that the *Salmo sebago* was the true *Salmo salar*, he might say that he had taken eggs of *Salmo salar*, impregnated them, hatched them, and taken them up into the rivers running into Lake Huron; and to-day some of the true *Salmo salar* were found in Lake Huron, though smaller than were found along the coast. That was evidence to show that you might make land-locked Salmon in any water you chose where the fish could find congenial food, and where they could not get to the sea. It might be said, How could the Salmon in Lake Ontario be said to be land-locked when the St. Lawrence emptied that lake into the sea? Salmon were feeders in the sea and breeders in fresh water; they migrated annually to the

rivers to reproduce. When they were abundant in the waters of the gulf, they passed up the St. Lawrence, entering every stream on either side up into Lake Ontario; and were it not for the great barrier of Niagara Falls the Salmon would be found in the upper springs of Lake Superior. It was their instinct to go onward and onward until they found a suitable spot for spawning, and they would have passed into Lake Erie and Lake Superior, the same as Lake Ontario, were it not for the Falls; the consequence was they entered into the smaller streams which fed the lake and went back into Lake Ontario instead of into the sea, where they had remained up to the present time, as the true sea Salmon only acclimatized to fresh water. Any gentleman in England who was desirous of having land-locked Salmon, if he had a lake with a great depth in the middle and small streams running into it, into which the fish could go to breed, might produce land-locked Salmon from the eggs of the Salmon of the sea.

Mr. BIRKBECK, M.P., on behalf of the Executive Committee, desired to thank Sir James Maitland for his excellent Paper, and also to thank Mr. Wilmot for his remarks on the question of State aid to Fisheries. He thought the advice he had given was most excellent, and only regretted that the House of Commons was not more largely represented. He could only hope that through the press the members of the Legislature would be able to read, mark, learn, and inwardly digest what had passed, and would persuade the Government of the day to recognise the importance of giving assistance to our fisheries. He could not specify any one particular direction in which that aid should be given, but he went on the principle that inasmuch as State aid was given in foreign countries and in our own colonies, the same assistance ought to be given in England.

The resolution was then put and carried unanimously.

Sir JAMES G. MAITLAND, in reply, said that he was very glad that his Paper had elicited remarks from the representatives of America and Canada, both of which countries were pre-eminently known for fish culture. He could not say that he agreed with all the remarks that had been made. Fishing was a very old art; fish had been caught ever since man went out in a coracle, but fish culture was still very young, and it would be expecting a great deal to expect Parliament to change legislation in a moment before this art had had time to approve itself to the nation. He quite agreed with the opinion expressed by Mr. Brady that so long as there was any doubt, they should not legislate. With regard to his hybrid experiments, they were yet too young to say exactly what might come of them, but they showed peculiar forms in scaling, and perhaps might help towards connecting different species of Salmonidæ and reducing them down to one or two species, the others being merely varieties. He was much obliged to Mr. Wilmot for his remarks on land-locked Salmon; but having had some experience on lakes in Scotland where Salmon had been bred and had not gone into the sea, he had found invariably that where there were no Char in the lake the Salmon had become very large in the head, and seldom exceeded four or five pounds in weight. On the other hand, some nine years ago he got a few eggs of the Leuvi Trout from the late Mr. Buckland, and turned about one hundred and fifty into a small piece of water a little over one hundred acres, which contained nothing but small Perch. Last Friday a gentleman brought him one of these fish, which he had found washed ashore, which must have been just nine years old; it measured 33¼ inches, but was in very bad condition. The Trout when put under con-

ditions of having shallow swimming fish beside it had obtained this enormous size, and he had no doubt it was absolutely necessary to land-locked Salmon to have shallow-swimming fish to feed upon. If they were not present in the water, they should be introduced first, and the *Salmo sebago* afterwards; this would make the experiment more successful. He concluded by proposing a vote of thanks to the Chairman, who had taken a great interest in the operations of the Fish Culture Association, of which he was President.

The Marquis of HAMILTON had much pleasure in seconding the vote of thanks to the Chairman. He could not but think that the speeches which had been delivered that morning would have the most practical effect on all those interested in fisheries. He hoped the observations made by Mr. Wilmot with reference to State aid being given to the fisheries of this country, would be earnestly taken up by the public at large, and that before many months had elapsed they would take a practical form, and be brought forcibly under the notice of Government.

The vote of thanks having been passed unanimously,

The CHAIRMAN assured the Congress it had given him the greatest pleasure to be of any use by occupying the chair. He had seldom presided at so interesting a meeting, or gained so much knowledge in so short a time. He must say he did not believe in land-locked Salmon as a distinct species. He believed you could produce a land-locked Salmon from the ordinary fish. He recollected when his uncle, the late Lord Spencer, had the shooting of Glenlochy, near Kilin, he recollected a quantity of parr and put them into a small tarn high up on the hills, where they remained for several years. When they went to fish this lake they saw a number of silvery-looking fish of about 2 to 3

lbs. in weight, jumping just like Trout would do. He believed those fish were the parr which were put in seven years before, which had turned silver, like Salmon. It was hoped they would continue to increase, but they became thinner, and gradually dwindled away. Before sitting down he must say a word in defence of the poor Black Bass, which had been so hardly used. He fully agreed with the remark that they should not be put into Trout streams, where they would be as destructive as Pike, but in many parts of England, particularly in his own country, there were neither Salmon nor Trout in the streams, only Pike, Perch, and the most abominable of all fish, coarse Bream. In those waters the Black Bass would be a useful addition, he would rise to a fly ; he would take any bait ; he would live with the Pike, and he was exceedingly good eating. They contained very few bones, and he thought the flesh was decidedly more like fresh Whiting than any other fish.

The Conference then adjourned until 2 o'clock.

THE HERRING FISHERIES OF SCOTLAND.

BY

R. W. DUFF, M.P.,
A LORD COMMISSIONER OF HER MAJESTY'S TREASURY.

CONTENTS.

CONFERENCE ON THURSDAY, JUNE 28, 1883.

SIR LYON PLAYFAIR in the Chair.

THE HERRING FISHERIES OF SCOTLAND.

IN the paper I am about to read on the Herring Fisheries, I do not propose to discuss the natural history of the herring, as that is a subject which at these Conferences, and elsewhere, has been amply dealt with by far more competent authorities.

I propose to treat the Herring Fisheries from a practical point of view, showing the progress of the industry, its national importance, and the requirements for the maintenance and further development of the most productive Fishery of the United Kingdom.

A knowledge of the natural history and habits of the herring is doubtless necessary for the proper treatment of the subject, even from the point of view I am attempting to deal with it, but scientific authorities differ in so many important matters concerning the natural history and migration of the herring, and so little is positively known on the subject, that I think it prudent to avoid controversial points of natural history, and to confine myself to such practical matters as have come under my notice in legislation connected with the Herring Fisheries,

and to such improvements for their development as a nautical experience of twelve years in the Navy suggests.

Now the treatment of the subject from the point of view I have indicated, necessitates a reference to statistics. I regret to say that the only reliable figures I can find are those relating to the Scotch Herring Fisheries, compiled by the Fishery Board for Scotland, and I may here remark that I think it is a matter of very great regret that no attention has hitherto been paid to the recommendation of the Sea Fisheries Commission of 1866, who say, "We think it a matter of great importance that Fishery statistics should be systematically collected. It is only by such means that the constant recurrence of the panics to which the Sea Fishery interests have hitherto been subjected can be prevented, and that any trustworthy conclusion can be arrived at regarding the effects of the modes of fishing which are in use. It is probable that the existing Coast Guard or Customs organisation may be utilised to collect statistics, as is now to some extent the case in Ireland."

The necessity for fuller information than we possess concerning our Sea Fisheries must, I feel sure, be impressed on us by the able and interesting paper read on Tuesday by Professor Brown Goode, as the result of the application of improved modes of capture and transit of fish in the United States could not have been established without the elaborate statistics he was able to put before us.

My general observations may be taken as applying to the Herring Fisheries of the United Kingdom, but for the reason I have mentioned they are made with particular reference to what is undoubtedly our most important Herring Fisheries, viz., those of Scotland.

Dealing, in the first instance, with the progress of the

Scotch Herring Fisheries I shall only take you back to the year 1810, when I find by the statistics of the Scotch Fishery Board the number of herrings cured were as follows:

	Barrels cured.	Barrels exported.
1810	90,185	35,848
1830	326,557	181,654
1850	770,698	340,256
1880	1,473,600	1,009,811

I may here mention that a barrel contains 32 gallons English Wine measure, and it is calculated that each barrel contains from 800 to 900 herrings. A barrel of salted herrings, taking the average of the different qualities, represents herrings to the value of 25*s.* According to this estimate the value of the herrings cured in Scotland in 1880 represents £1,842,000. It is calculated that 20 per cent. of the herrings are sold fresh, assuming the fresh herring to be only worth as much as the cured, although it is probably more valuable, the total quantity taken off the Coast of Scotland in 1880 would represent a money value of £2,210,460.* In the valuable paper prepared for this Conference by the Duke of Edinburgh, His Royal Highness estimates the money value of the fish taken off the Coast of these Islands at £7,380,000. It will thus be seen that the produce of the Scotch Herring Fisheries bears a large proportion to the total value of the fish brought to our shores.

The Herring Fishery of 1880 was the most productive ever experienced in Scotland, and it was one which enabled

* Professor Brown Goode estimates the American Oyster Fisheries as producing £2,799,790 a year, £589,330 more than the Scotch Herring Fisheries, the latter being twice as valuable as any other single American Fishery.

the Scotch curer to export a greater quantity of cured herrings to the Continent than either the Norwegians or the Dutch, who have long been the established and worthy rivals of the Scotch in the Continental markets. I find, from the statistics laid before the Herring Brand Committee of 1881, the relative quantity of herrings imported at Stettin was:

	Scotland.	Norway.	Holland.
1869 to 1874, average of 6 years	569,741	936,105	161,961
1875 „ 1880 „ 6 „	629,101	694,502	148,663

The Norwegian barrel is $\frac{1}{6}$th less than the Scotch; the Dutch barrel is the same size.

These figures do not, of course, represent the total export of each country. A quantity of Dutch herrings are sent up the Rhine, and Holland, like Norway and Scotland, has a considerable export trade in cured herrings with most European countries. The Baltic ports, however, take the large proportion of the Scotch and, I believe, also of the Norwegian herrings; a comparison, therefore, of the imports at these ports may be taken as indicating the relative prosperity of the herring trade of the two countries. The demand for cured herrings in the interior of Europe may be shown by a statement of Mr. Reid, the British Vice-Consul at Stettin. Speaking of Scotch herrings imported at Stettin, he said, before the Committee of 1881: "We send them all round, beginning with Poland and Warsaw and the territory between Stettin and Warsaw, the south of Russia, Gallicia, round by Vienna, along to Bavaria, and then as far round until we get to Magdeburg, when the imports of Hamburgh come in and compete with our offers."

The progress of the Dutch Herring Fisheries is indicated by the statistics in the Exhibition, showing that since 1857

they have increased in value from £47,908 to £147,788 per annum.

Returning to the Scotch Herring Fisheries, I should mention that the herrings cured in 1881 (the last year for which I have reliable statistics) showed a decrease as compared with 1880, of 362,445 barrels, but an increase as compared with the average of the last ten years of 21 per cent.

Besides producing the large revenue I have referred to the Scotch Herring Fisheries give employment to 48,000 fishermen, 2,400 coopers, 18,854 salters and packers. There are 14,800 boats employed, while the value of the boats, nets, and lines is estimated at £1,500,000.

An industry conducted on so large a scale must be of great value to any country. It is difficult to exaggerate its importance to the North of Scotland, where the industries are few, and where the soil is frequently sterile and unproductive.

Professor Huxley in his opening address referred to the large proportion of food frequently taken from the sea as compared with the land. This is well illustrated by the relative products of our Northern Counties.

I once made a calculation, taking my figures from the Domesday Book, that the annual rental of the nine Northern Counties in Scotland, amounted to £1,299,704, being half a million less than the value of the cured herrings in Scotland, already referred to, in 1880, and the value of herrings cured at three stations, in the same year, on the Aberdeenshire Coast, viz.: Aberdeen, Peterhead, and Frazerburgh, exceeded the rental of the County of Aberdeen (the City of Aberdeen alone excepted) by £69,000.

The statistics I have given I think prove the national importance of the Herring Fisheries, they also show that the progress of the Scotch Fisheries, although subject to

some slight fluctuations, has been rapid and continuous. I will now consider the conditions under which they have prospered and under which the trade in cured herrings has so greatly increased.

The Herring Fisheries Commission of 1878 reports that up to 1829 it had been the policy of the legislation to encourage the Herring Fisheries by bounties, but the bounties were discontinued, Mr. McCulloch expressing an opinion that the fishermen often went to sea to catch the bounties and not the fish.

From 1829 to 1851 the Fisheries were free from Government sources of encouragement and were subject to no restrictive regulations of importance. From '51 to '67 a series of restrictive measures were passed to regulate the Fishery and to prevent the capture of herrings at certain seasons and in certain ways. Since 1867, again, when the first of the liberating Acts were passed (due in a great degree to the report of the Commission in '62, presided over by my right hon. friend in the chair), the Fisheries on the coast of Scotland have practically been free and subject to no restrictive legislation whatever.

I find that from—

			Average number of barrels cured annually.
1829–51,	period of	unrestricted fishing .	521,880
1851–68	„	restrictive legislation .	657,160
1868–1881	„	unrestricted fishing .	827,580

These figures show that the average increase per annum in 13 years of unrestricted legislation exceeded that of 17 years of restrictive legislation by 170,420 barrels.

The two systems were tried for sufficient periods to justify the conclusion of the Commissioners of '78, viz.—"That legislation in past periods has had no appreciable effect, and that nothing that man has yet done, and nothing

man is likely to do, has diminished or is likely to diminish the general stock of herrings in the sea."

If further evidence be needed in support of a policy of unrestricted fishing, it appears to me to be supplied by a consideration of the insignificant proportion of herrings captured by man as compared with that effected by agencies over which man has no control. I need say little on this point, as it was amply dealt with by Professor Huxley in his opening address, but in support of his view I may quote a short extract from the Report of Messrs. Buckland, Walpole and Young in '78. They say: "The Scotch gannets must consume 37 per cent. more herrings than all the Scotch fishermen catch in their nets."

The Commissioners add: "Whales, porpoises, seals, coal fish, predaceous fish of every description are constantly feeding on them (the herrings) from the moment of their birth. The shoals of herrings in the ocean are always accompanied by flocks of gulls and other sea birds, which are continuously preying upon them, and it seems therefore no exaggeration to conclude that man does not destroy one herring for every fifty destroyed by other enemies." In quoting these opinions I am aware that I am only repeating what has frequently been urged before by those who have advocated unrestricted freedom of fishing. My apology for repetition is that I am often being told that "the sea is over-fished," and am frequently appealed to to use my influence in Parliament in support of various restrictive measures for regulating our Sea Fisheries, and the most effective reply to these statements and demands appears to me to be the conclusions arrived at by competent Commissioners, who have made exhaustive inquiries into the subject. Only the other day I read a most interesting book which I purchased in the Exhibition,

entitled "The Herring, and the Herring Fisheries," by Mr. de Caux. Mr. de Caux is quite at one with me as to the impracticability of establishing a close time, but he proposes to re-enact the provision contained in the 48th of Geo. III., Chap. 110, regulating the size of the mesh of the herring net. Now this question is very exhaustively dealt with by the Commissioners of 1878. They point out that a law regulating the mesh could not be enforced, except by an International Convention, beyond three miles from the shore. A new Convention has just been concluded with Foreign Powers, and a Bill is now before Parliament to give effect to it, but the Convention declined to entertain the question of the mesh.

Another objection to reducing the size of the mesh is that such a regulation would interfere with the sprat and garvie fishing. I may here assume, without raising any controversial point, that sprats and garvies are not young herrings. Sprats and garvies supply a considerable amount of wholesome food, and it would be unfair to prohibit these fishings on the mere chance of increasing the number of herrings.

A further objection is that the cotton nets, now in universal use, are subject to shrinking at every fresh barking, and fishermen might thus unwittingly be led into an infraction of the law. These difficulties to regulating the size of the mesh, combined with the experience we have had of legislative enactments in Scotland, cause me to differ on this point with Mr. de Caux.

The Act which he desires to pass for the English fisheries is still nominally in force in Scotland, but for the reasons I have stated it has been found to be inoperative, and the newly organized Scotch Fishery Board in their first report, issued last month, recommend the repeal of the

section that Mr. de Caux wishes to enforce. They say: "In many cases a net below the standard size is in use; but the fishermen are finding that the small mesh is not profitable, as only the nose of the larger fish gets into it, and unless they get past the gills they are not effectually caught. The matter does not seem to be one suitable for public regulation, and had much better be left to the fishermen themselves. We therefore recommend the repeal of Sec. 12 of 48 Geo. III., Chap. 110."

Legislators received some very wholesome advice from Professor Huxley at the close of his opening address, when he said: "I think that the man who has made the unnecessary law deserves a heavier punishment than the man who breaks it." Now, although some of the laws we have passed to regulate our Herring Fisheries have been harmless, except for bringing the law into contempt, yet this cannot be said of all our restrictive legislation, as the Sea Fisheries Commission of '66 describes the effect of the close time established by Parliament on the West Coast of Scotland, as "reducing the population of some of the Western Islands to misery and starvation, while abundant food was lying in front of their doors, by preventing them taking herrings." Surely Parliament can be better employed than by mischievous legislation, producing such vexatious results.

The statistics I have quoted indicate the general prosperity of the Scotch Herring Fisheries, but this general conclusion must be accepted with some qualification. The Commissioners of 1878 remark that the so-called prosperity is almost entirely due to the extraordinary development of the fisheries off the Aberdeenshire coast; and if the takes between Fraserburgh and Montrose be deducted, the condition of the other fisheries will be found to be much less

satisfactory. Commenting on this, the Commissioners observe that the development of the fisheries on the Aberdeenshire coast has led to the neglect of fisheries at other places, the younger and more vigorous fishermen being attracted to the most productive fishing ground. The destruction of the Wick Harbour has caused many of the boats from that district to fish off the Aberdeenshire coast.

These causes have contributed to the falling off of the fisheries elsewhere. But allowing for these considerations, the Commissioners express an opinion that the vast amount of netting now in use may have scared the fish from narrow waters. They estimate the nets used by the Scotch herring fishers to be sufficient to reach in a continuous line for 12,000 miles, to cover an area of 70 square miles, and to be sufficient to go three times across the Atlantic from Liverpool to New York. The substitution of cotton for hemp nets may be said to have revolutionised the fishery. A boat that used to carry 960 yards of netting, now carries 3,300 yards. The nets used to be 6 or 7 yards, they are now 10 yards deep. They used to present a catching surface of 3,000 square yards, they now present a catching surface of 33,000 square yards; without increasing the weight of the nets to be worked, each boat has increased its catching power fivefold. This vast extent of netting certainly warrants the possibility assumed by the Commissioners, that the nets may have scared the herrings from narrow waters, but looking to the general results, they decline to recommend any restrictive measures, entertaining an opinion that the vast amount of netting has no effect in diminishing the stock of herrings in the sea; a conclusion amply justified by the enormous take of herrings in 1880, two years after the Commissioners' Report. Since then herrings have also returned in greater number to some of

our inshore fisheries. Referring to the west coast, the Fishery Board Report for 1881 mentions that "The best fishing was got in Loch Hourn, where an immense body of herrings remained all the season." It is reasonable to assume that the herrings returned on their own account, and that their movements were made in "blissful ignorance" that the British Parliament had abolished the measures for their special protection.

Another feature of the Scotch Herring Fisheries is the large and continually increasing takes of late years off the Shetland Islands. In 1879 the Shetlanders only cured 8,000 barrels; in 1880 the number had increased to 48,000; in 1881 to 59,586, and in 1882 to 134,000 barrels.

In his opening address Professor Huxley remarked that considering the antiquity and importance of the fishing industry "it is singular that it can hardly be said to have kept pace with the rapid improvement of almost every other branch of industrial occupation in modern times. If we contrast the progress of fishery with that of agriculture, for example, the comparison is not favourable to fishery," and he afterwards observed, "But we are still very far behind scientific agriculture; and as to the application of machinery and of steam to fishery operations, it may be said that in this country a commencement has been made, but hardly more."

I am not going to question the general accuracy of Professor Huxley's conclusions, yet I think that I have shown that our Scotch Herring Fisheries have not been altogether standing still. The increase in our take of herrings has not been entirely due to the larger amount of capital invested in the trade, nor to the enterprise of our fishermen in going further to sea in pursuit of their calling; though no doubt these two causes have largely contributed in

raising our fishery to its present importance. But of late years the boats have been very much improved, and the cotton nets, as I have already said, worked almost a revolution in the Herring Fisheries. The effect of these combined causes, better boats and better nets, will at once be appreciated by a reference to a table compiled by Dr. Francis Day (from the Scotch Fishery Board statistics), and published in his notes, giving an account of his cruise in the *Triton* last year.

Dr. Day gives the proportion of barrels of cured herrings to the fishermen employed since 1825 :—

	Fishermen.	Barrels.
5 years, 1825–30	1	8
5 " 1854–59	1	14
5 " 1876–81	1	22

One fisherman now produces nearly three times what he did fifty years ago, and the result of his labour will bear favourable comparison with the increased production of the agricultural labourers during that period. I am, however, quite at one with Professor Huxley in believing that our sea fisheries are capable of far greater development, particularly by the application of steam power. On this point, I may be permitted to quote some opinions I expressed in a lecture I gave about two years ago, when I advocated the application of steam power as a means of developing our Herring Fisheries.

What I claim for steam is :—

1. A saving of life by increasing the boat's chance of making a port of safety in bad weather.
2. A certainty of reaching and returning from the fishing ground in all ordinary weather, independent of tides, calms, and head winds.
3. The comparative punctuality thus acquired by

steam would enable arrangements to be made by railways to run fish trains, and so enhance the value of the cargo by the difference between the price of fresh and cured fish.

In the foregoing remarks I have assumed that each boat should be propelled by steam power—an auxiliary screw would be the most suitable. Steam might also be applied to a winch, and would save a deal of manual labour in hauling the nets. Steam tugs, to tow the boats, have been tried with only a moderate degree of success. As a means of saving life by getting the boats into harbour in a storm they are not to be depended on, and at any time might miss the boats during a fog or in a dark night. Steam carriers do not appear to me to be adapted for the herring fisheries. The transhipment of herrings from the present boats to carriers, except in very smooth water, would be attended with great difficulty. How steam can be best utilised in developing our herring fisheries is a question I should be very glad to hear discussed at this Conference. It is one of great and growing importance.

Our first-class boats, annually in some parts of Scotland going further to sea, are too heavy to be propelled by oars; consequently, in calms or when a tide has to be encountered, the cargo of herrings is frequently spoilt before it reaches the shore. The regulations of the new Fishery Board are framed to facilitate the curing of herrings at sea, but our present boats are not large enough to carry barrels and salt enough for this purpose. Off the coast of Montrose, where I believe our boats often go seventy to eighty miles to sea, I am told that it is now the practice to carry salt enough to sprinkle over the herrings, and thus save them for four or five days; and I understand that herrings treated in this method, termed "salting in bulk," are but

slightly depreciated in the market; but herrings so cured would not be entitled to receive the Government "brand" or mark, the regulation for this purpose requiring that the fish should be cured within twenty-four hours of being caught.

The Government brand, indicating a degree of quality, was first established in 1808, but nothing was charged for it till 1859, when the Government imposed a fee of 4*d.* a barrel to defray the cost of the branding establishment. The amount collected from the fees exceeds the cost of branding by about £3,000 a year, and this surplus is now paid to the Scotch Fishery Board for harbour improvements and other objects to develop the fisheries.

The policy of a Government brand has been the subject of frequent contention among the Scotch curers. The matter was fully discussed so recently before a parliamentary Committee, of which I had the honour to be chairman, that I do not propose to detain you to-day by reopening the question.

The Committee referred to reported in 1881 in favour of the retention of the brand. It was contended by its opponents that the brand had lost its value, but the Committee considered "the continental merchants would not continue to demand branded herrings, and the home curer would not voluntarily pay 4*d.* a barrel for a trade mark which had ceased to be a guarantee of quality." I should mention that the brand is not compulsory; and if any of the Scotch curers consider they can establish a superior trade mark—and some of them are of opinion that they can—they are at perfect liberty to do so.

The Dutch cure most of their herrings at sea, on board much larger vessels than are generally used by our fishermen, but I should regret to see the adoption of a system

here by which the fish offal was all lost, as it forms an excellent manure, which, by a process shown in the Exhibition, might, I believe, be made still more valuable. The result of the experience obtained at the Menhaden Fishery, detailed by Professor Brown Goode, is instructive, as showing the extent to which fish offal may be advantageously utilised.*

The use of larger boats necessitates increased harbour accommodation, and this is at present the great want of fishermen all along our coast. How it is to be supplied is too large a question for me fully to discuss in this Paper. There can be no doubt, especially after the experience we have had in this Exhibition, of the demand on the part of the public for an abundant supply of cheap fresh fish; I am not, however, aware to what extent the community is willing to be taxed for the construction of better harbours to facilitate a supply of food so universally appreciated, but without better harbours I believe it will be impossible for

* "In 1878 the Menhaden Oil and Guano Industry employed capital to the amount of 2,350,000 dollars, 3,337 men, 64 steamers, 279 sailing vessels, and consumed 777,000,000 of fish. There were 56 factories, which produced 1,392,644 gallons of oil, valued at 450,000 dollars, and 55,154 tons of crude guano, valued at 600,000 dollars; this was a poor year. In 1874, the number of gallons produced was 3,373,000; in 1875, 2,681,000; in 1876, 2,992,000; in 1877, 2,427,000. In 1878, the total value of manufactured products was 1,050,000 dollars; in 1874, this was 1,809,000 dollars; in 1875, 1,582,000 dollars; in 1876, 1,671,000 dollars; in 1877, 1,608,000 dollars; it should be stated that in these reports only four-fifths of the whole number of factories are included. The refuse of the oil factory supplies a material of much value for manures. As a base for nitrogen it enters largely into the composition of most of the manufactured fertilisers. The amount of nitrogen derived from this source in 1875 was estimated to be equivalent to that contained in 60,000,000 lbs. of Peruvian guano, the gold value of which would not have been far from 1,920,000 dollars."—*Professor Brown Goode's Paper at International Fisheries Exhibition.*

the fishermen to meet the growing demands of an increasing population. State aid towards harbour improvement has hitherto been most successful, when given in the form of grants to supplement local efforts, or by loan at a low rate of interest. Under this system, which I should like to see extended, such harbours, and they are miserably inadequate, as are available for our Herring Fisheries, have been mainly constructed. In Scotland generally, the fishermen have shown a commendable spirit of self-reliance by combining together to raise funds for the improvement of their harbours. I have often been astonished at the efforts they have made to enable them to participate in the small grant annually given to the Scotch Fishery Board.

I may mention one instance that lately came under my notice. About two years ago I was visiting a small fishing hamlet on the coast of Banffshire. I was told that the fishermen were most anxious to raise a sum of £3,000, to enable them, by the assistance of the Fishery Board, to improve their harbour. I remarked to a friend who was with me, that there seemed to be nobody but fishermen in the place, and I expressed some doubt as to their ability to raise the required sum. His reply entirely confirmed my estimate of the inhabitants, for he said, "No one here puts on a black coat on the Sabbath except the minister and the general merchant." Yet the amount required, with some assistance from the landlord, was duly raised, and by the aid of the Fishery Board a harbour, which will be of great advantage to the district, is now being constructed. I mention this circumstance because I think the willingness of the fishermen to pay, so far as in their power, for improved harbours, is a consideration which should be taken into account in any general scheme for harbour construction, and also because I think the spirit of self-reliance

evinced by the fishermen entitles them to the sympathy and to the support of the public.

I should like to say a word before concluding this Paper on the distribution of the vast number of herrings taken off the Scotch coast. The Duke of Edinburgh estimates the value of the fish taken by the trawlers off the coast of the United Kingdom at £2,581,000, or about £300,000 more than the value of the herrings taken off the Scotch coast. Cured herrings, representing £1,006,462, were exported in 1881, the value of the other fish exported that year from all parts of the kingdom was only £398,048. It will thus be seen that the distribution of the herrings is very different from that of other fish. I believe a far greater proportion of the Scotch herrings, especially those caught on the west coast, would be consumed as fresh fish at home, if greater facilities were given by the railways for their conveyances.*

The evidence given before the Railway Committee last year, fully exposes the high rates frequently imposed by

* "Still more important has been the general adoption of scientific methods of preparation and transportation. Great freezing houses have been built on the Great Lakes, on the Pacific coast, and in the cities of the East, and refrigerator cars are running upon all the trunk lines of railway. Columbia salmon, lake white-fish, cod, bass, Spanish mackerel, and other choice fishes are frozen stiff and packed up in heaps like cordwood, and can be had at any season of the year. Refrigerator cars carry unfrozen fish from sea and lake inland. Smelts and trout, packed in snow in the north, are received in New York by the cartload daily throughout the winter. Halibut are brought from the distant oceanic banks in refrigerators built in the holds of the vessels, and 12,000,000 to 14,000,000 pounds are distributed, packed in ice, to the cities of the interior. Baltimore, from September to April, sends special trains laden with oysters, daily, into the west, and Chesapeake oysters are food for all, not luxuries, even beyond the Mississippi."—*Professor Brown Goode.*

the railway companies for the carriage of fresh fish. A less grasping policy would, I believe, be more remunerative to the railways and certainly more advantageous to the public. But this is a subject which will be more fully discussed in a subsequent Paper by his Excellency Mr. Spencer Walpole.

The conclusion I arrive at is, that the requirements for the further development of our herring fisheries are:—

1. Better harbour accommodation.
2. The application of steam power.
3. Increased railway facilities, and lower railway rates for the distribution of fresh fish.

As my right hon. friend Mr. Shaw-Lefevre, M.P., is to read a Paper on the "Principles of Legislation in connection with Sea Fisheries," I have not alluded to the laws relating to trawling, and other matters for regulating our sea fisheries; I have only touched on a subject, which I am sure will be more ably dealt with by my right hon. friend, to such an extent as I deemed necessary to make the condition of our herring fisheries intelligible before an International Conference.

Regarding the objects in the Exhibition calculated to develope the herring fisheries, there are models of boats of the most approved build propelled both by steam and sail, nets of the most improved pattern, conspicuously among them being the American purse-seine net, admirably adapted, in the opinion of some competent practical men with whom I inspected it, for the herring fisheries; there are refrigerating vans, and barrels made by steam machinery.

But more important to my mind than the modern appliances I have referred to for the capture and transit of fish are the conclusions arrived at by the competent autho-

rities who have addressed us at the Conference, viz., that the stock of herrings in the sea, so far as man is concerned, is practically inexhaustible. The opinion expressed by the Playfair Commission in '62, by the Sea Fisheries Commission in '66, by the Herring Fisheries Commission in '78, is confirmed by the exhaustive enquiries of the Duke of Edinburgh, and by the ripe experience of Professor Huxley. Although we cannot account for the mysterious movements of the herring, causing the fluctuation which characterise our fishery, it is at least some consolation to know on the high authorities I have mentioned, that although advancing civilisation may pollute our rivers and destroy our salmon, we are still likely to enjoy our herring, as the inventive genius of the age has failed to discover any means of depriving us of an ample supply of the most abundant and nutritious food which the bounty of the ocean yields to the labour of man.

DISCUSSION.

The CHAIRMAN said his honourable friend had treated the subject as he had expected he would from the intelligent action which he had taken in Parliament in promoting regulating but not restrictive laws, with regard to sea fisheries. The only reason he presumed why he found himself in the Chair on this occasion was, that in 1862 he was Chairman of the Royal Commission for examining into the herring-fisheries of the British coast. Why he, a Chemical Professor, should be found in that position, he could never fully understand, especially as there was on the Commission a man of European eminence, and of the greatest authority on fisheries: though they both

were in the same galley, and he sat at the helm, it was the vigorous power of his friend, Professor Huxley, who not only impelled the bark, but also directed it. That Commission established one or two facts which certainly had been of the greatest importance to our great fisheries, viz., that restrictive laws framed by man in ignorance of the laws of Nature, were excessively destructive to the interests of fishermen instead of being favourable to them. When they first began to examine this subject, they found different laws prevailing on the east coast of Scotland to those which prevailed on the west. On the east coast there were no restrictive laws, and fishermen were encouraged to catch fish, even full fish containing ova, in order to be cured. Each of these fish had on an average 50,000 eggs, and the enormous number that were taken in this state would seem to indicate a process of extermination; but the fisheries of the east coast, without restrictive laws, increased, and did not diminish. When they went to the west coast of Scotland, however, in the inner waters of the Firth of Clyde, they found restrictive laws prevailing. For several months no herrings were allowed to be taken, there being a close time for herrings for the purpose of protecting them. As they went further into the open waters at the Firth of Forth and Clyde along the islands up to near the Highlands, those restrictive laws still prevailed; but there was a relaxation as to the period when the close time should end. A very curious result was made apparent, and a most unexpected one. At the periods of close time, the herrings came to the banks to spawn, and were followed by their natural enemies in great number, among which he might chiefly allude to the cod and the ling, which consumed them in great numbers. There were innumerable fish which lived upon the young

fry and the full-grown herring; the cod, ling, dog-fish, and conger, fed on the full-grown herring; while the flat-fish and crabs eat the spawn, and there were innumerable other fish which eat herring-fry. At the time when they found them on their spawning banks, these fish had an appetite for nothing else but herring, and this result followed, that the fishermen of cod and ling could catch nothing, because they would only take herring bait at the time, and the close time prevented the fishermen getting any herring-bait for catching this white fish. The consequence was, that the laws invented for the protection of the herring became laws for their destruction, because their natural enemies, which could not be caught because of the want of bait, multiplied exceedingly, and devoured the very herrings which the laws intended to protect. This was so to an enormous extent, as a little calculation would show. The Commission frequently opened cod and ling and examined the contents of their stomachs, in which they frequently found seven to ten herrings, which they had not begun to digest; but allowing a diet of two herrings a day to a cod, and allowing him to live seven months in one year, fifty cod would catch as many herrings as one fisherman could catch in a year. Now there was no census of how many cod and ling existed, but there was a census of how many cod and ling were caught; there were caught and salted last year on the coast of Scotland, 115,513 cwt. of cod and ling. Now about thirty fish went to a hundredweight, and from a little calculation it would follow, that if the cod and ling which were salted had lived in the sea, and had not been taken, they would have caught as many herrings as 69,000 fishermen. Now that was more than 20,000 beyond all the fishermen who existed on those coasts, and, therefore, those laws which protected the enemies of

herrings, kept them in the sea, and produced this enormous loss. That was one of the results of the Commission; for the laws intended for the protection of herring really multiplied the natural enemies of the herrings enormously, and thus destroyed them infinitely more than they were protected. The action of that was this, that under the protection of these laws, the fish which preyed on the herring increased and multiplied exceedingly, so that they had a very good time; but the poor fishermen of those coasts had a very bad time, because they could not catch the fish upon which their subsistence depended. The consequence was, that they found these fishermen disobeying the law, when it could not be enforced, or when the law was obeyed, it led to starvation, and they were obliged to emigrate. That was the result of interfering with the laws of nature by an indiscreet law passed by Parliament. The lesson which might be drawn from the interesting paper just read, was that though Parliament might make laws for keeping order and safety amongst fishermen; that the balance of nature which prevailed in the sea should be left alone, because the balance of animal life depended upon unknown factors. The herrings had for their food small crustaceæ, sometimes microscopic, but at other times little shrimps and sand-eels. They enjoyed that food, and when it existed on the coast, multiplied largely; but whilst they lived on these things, there were other fish which were living on them, and which had the greatest love for the herrings. They were the conger, the dog-fish, the cod, and the ling, which slew their millions, and there were birds, such as gulls and gannets, which also destroyed multitudes, and then there were the porpoises and grampuses, which ate up whole shoals of herrings. This was the balance of life, one balancing the

other, and the more it was interfered with, the more mischief resulted. Sometimes there was a cry for protective laws, because the herring fishery varied as any other industry varied according to circumstances. They did not always know why it varied. For instance, Mr. Duff spoke about the varying character of the herring, and a very capricious fish was the usual term fishermen applied to it. But the term caprice was merely the mode of concealing our ignorance of its habits. If we knew its habits, and those of its enemies, it would probably be found there was no caprice in the matter. Sometimes herrings came in shoals to particular parts of the coast, and other times they abandoned them for many years. The reason of that was not known. It might be, for instance, that something had happened to the small crustaceæ and the sand-eels on the particular part of the coast, and the herrings did not find their natural food ; it might be that the enemies of the herrings had multiplied very much, and devoured in too large quantities their own subsistences. Then the herrings decreased, but ultimately they increased again, because their enemies having fed too largely upon them, they decreased in number, and then the herrings had their turn again, and so there was a continual scarcity and plenty in the markets, sometimes prosperity and sometimes a panic, and the herring in its action assisted in producing these cases of prosperity and panic, just as if they were Lancashire manufacturers. It was needless, therefore, to make laws to try and prevent man, who was such a very small factor in the result, catching herrings when there were, all round the herrings, enemies creating havoc infinitely greater. If any lesson could be learnt from the interesting paper they had listened to, it was that it would be much better to leave these things to the laws of nature, which were far more

wise in this respect than any laws which were likely to be passed by Parliament.

Dr. FRANCIS DAY did not know whether it was worth while making many remarks on the question if they were told that all legislation was useless, and that whoever said anything on the other side appeared to be one who did not understand the subject upon which he was speaking; but he thought they were met for the purpose of discussion, to hear both sides of the question, and not to jump to conclusions at the commencement before they had heard what the other side had to say. Personally as yet he gave no opinion on one side or the other, but he did think those who had opinions to offer should be allowed to give them without being told that those who made laws ought to suffer from them themselves instead of the unfortunate fishermen to whom those laws would apply. He could not help thinking that gentlemen who held those views, though they might be very fit for Legislatures, were quite unfit to legislate on fishing matters. It was only necessary to look at the fresh-water fisheries to see how they had been destroyed for want of legislation, and what had been done by making use of legislation. He would, however, pass on to the subject more immediately before them; he had no intention of making any remarks when he entered the hall, but he had been at two or three conferences when no one had risen to say anything, except the proposers and seconders of resolutions, and he thought it was time that a few observations should be made on the different sides of these important questions. They must all feel exceedingly obliged to Mr. Duff for the figures he had given, but when he left out the natural history of the subject it appeared to him that he left out the most important portion of the question with regard to herring and other fisheries. There

were three different classes of fish from the sea which were mostly made use of by man. There were the herrings, the gregarious form, which were mostly found near the surface, and with them might be classed the mackerel and the pilchard, and then there were the deep sea form of the cod and ling which had been mentioned, the devourers of the herring, and also the ground fishes, such as the turbot, sole, &c. Some people talked about the balance of nature, and said no law should be passed with reference to these fisheries, but the question was whether by passing no laws they were not destroying the balance of nature. They permitted the cod and these voracious fishes to be captured in large quantities, and these were the very fish which, as the Chairman informed them, ate the herring. Might it not be that if, as many fishermen told them (though it was denied on some hands, as far as he had seen, it appeared to be correct), the inshore fisheries were decreasing, the quantity of cod was decreased, and so the fish were destroyed which were catching the herring, and thus the herring might be increasing in consequence of the destruction of the cod fisheries. Then they were told that in consequence of the legislation the poor fishermen suffered on one portion of the coast of Scotland and not on the other, but if they turned to the blue book issued by Messrs. Buckland and Walpole it would be found that although these regulations were in existence they were never carried out; that no regulations ever passed by man had ever had any effect on the herring fisheries. Then they were told that the herrings were inexhaustible. They found the herrings migrating from place to place, and in so doing they disappeared entirely from one country and appeared in another. If the cod fisheries were destroyed and the herrings migrated, where would the fisheries be? He had

seen the oil sardine on the western coast of India for years, and all of a sudden it would entirely disappear and not appear again for several seasons. With regard to the size of the mesh he would not attempt to offer any opinion, seeing there were so many gentlemen present more competent to speak upon it. It appeared to him that if the herrings were driven out from the inshore fisheries into the open sea there was a necessity for larger boats, and if this resulted, and there was not an increase of harbour accommodation, what were the fishermen to do on the eastern coast of Scotland? They must be driven down to the ports or beach their boats, which often caused loss of life. He thought, instead of taking all the facts given in these Royal Commissions for granted, they ought to have them supplemented by further investigation. If investigations were carried on in the way in which they were in the United States, so as to ascertain whether any class of fish were increasing or decreasing, what they fed upon, and what it was which caused their food to increase or decrease, or to migrate, they would then be in a better position to judge as to the necessity for legislation on this subject.

Mr. BRADY (Inspector of Irish Fisheries) said he had listened with great pleasure to the excellent address which had been given, and it was certainly a question of very deep interest whether, as we went on increasing our means of capture, and increasing the amount of food brought up from the ocean, we might not be considered to be killing the goose which laid the golden eggs. He had had the honour on two occasions of mentioning certain facts connected with two bays in Ireland, from which he drew certain conclusions, which, of course, might be incorrect, but those conclusions were that all restrictions on deep-sea fishing

were mischievous, and tended to no good. If he understood aright the observations of the last speaker, he said the regulations in Scotland had no effect on the herring fishery. There had been restrictions, and the Chairman had made some very important observations with regard to them. Dr. Day said they were not enforced, and, therefore, they had no effect. Well, if they found the herring fisheries of Scotland increased in the vast proportions that they had done for so many years, it was the strongest argument that the restrictions placed upon them by the Legislature were of no avail, and did no good. How far, if they had been enforced, they might have done any good, of course no one could say. It was most important that science should be brought to bear on this question, and should be aided by practical experience. When they had arrived at the time when scientific men could say that certain restrictions should be placed on deep-sea fishing, then it would be time for the Legislature to step in, but until that day came it would be only mischievous to cripple the industry of a country by imposing such restrictions in the absence of that knowledge which they all admitted they were deficient in. The great deficiency of statistics had been referred to especially with regard to Ireland, and he regretted very much to say that the statistics of fisheries in Ireland were miserably defective. It was very important that those statistics should be collected, so that they might ascertain whether the improved modes of capture and the greater distance to which the boats went were injurious to the fisheries. Nothing was more interesting to him than something which he had seen in the Exhibition, which might develop the fisheries to an enormous extent. He alluded to a mode adopted on the great lakes in Canada, by which a steamer, while moving on, kept paying out one net, and at the same time hauled

in another. If that could be brought into operation in our sea fisheries it would lead to very important changes.

Mr. McLelan (Canada), said that some of the fishing grounds on the great lakes in Canada, where the mode of fishing just referred to was adopted, were 400 or 500 miles long; and the reports coming from fishermen were, that unrestricted fishing diminished the number of fish even in these large lakes. Application had been made to him repeatedly to permit a smaller sized mesh of net to be used; but in consequence of the testimony which had come to him from all fishermen, he had refused to allow it. He considered it was a very important question whether sea fisheries were exhaustible or not; probably the most important question which could be discussed. Previous to coming to England, all the testimony he had received from the fishermen of Canada, both shore fishermen and sea fishermen, was, that on the great lakes, fisheries that had hitherto been very profitable, were being exhausted from over-fishing, and from all he could hear from fishermen all round the coast, he had come to the conclusion that it was possible to exhaust the fisheries of the Dominion of Canada. Mr. Duff had told them that with regard to herrings they first had an open season, in which an average of 500,000 barrels of fish were taken every year; then for some seventeen years they had a close season, in which there was an average of 600,000 barrels, and then it was made open again, and the average rose to 800,000 barrels. The inference from all this was, that it was better to have free fishing; but at the same time the honourable gentleman stated that the appliances for catching the herrings had been multiplied fivefold, and it occurred to him that if that were so, they ought to have had three million barrels

of fish instead of 800,000, seeing the appliances had so largely increased. Then the question arose, with these multiplied appliances and the improved boats which had been referred to, was it not the fact that they went further to sea, and were sweeping over a larger area and not getting a proportionate return of fish? This was a point on which the testimony of practical men was needed. Science told them that fish produced so many eggs, and multiplied very fast; that one fish fed on another; and that the balance of nature ought to be preserved; that the little fish had larger fish to eat them; the larger fish had bigger ones to bite them, and so on *ad infinitum;* but they left out of sight a certain kind of fish which preyed on the others, but were not fit for food and therefore were not caught. To keep up the balance of nature they ought to fit out expeditions to destroy those fish which preyed on the edible fish; but if they left them to multiply and prey on the others, and at the same time man went in with his fivefold machines to catch the herrings, the result would be, according to the testimony of Canada, that the fishing grounds would be gradually destroyed. It would simplify things on the other side of the Atlantic very much if it could be settled, by the testimony of fishermen and the investigations of science, that the sea fisheries were inexhaustible; then all they would have to do would be to improve their appliances for catching. Mr. Duff had referred to the want of harbours round the coast, and if he might be permitted to give the experience of a young country, he might say that they had felt the same want in Canada; but there the Government took hold of the matter, considering it of great public importance that the fisheries of the country should be protected, and that suitable harbours should be provided. Year by year large grants were made for the erection of

suitable breakwaters and harbours of refuge, with the most beneficial results. He did not pretend to argue the advisability of this system in a country where it was the State policy for every industry to be left to its own resources; but in Canada, which might be considered more protective of native industries, that course had been pursued, and fishermen had been protected not only by the providing of harbours, but by the distribution yearly of a quarter of a million of dollars in the encouragement of fisheries.

Mr. RONALD MACDONALD (Aberdeen), said the views of gentlemen from England, Ireland, and Canada had been heard, and as he came from Scotland, where the herring fisheries were more important than in either England or Ireland, he hoped he might be allowed to make a few remarks. He knew a number of Mr. Duff's constituents, who appreciated very much the great intelligence and practical interest he had taken in the development of fishing in Scotland, and he had listened with great pleasure to the comprehensive paper which he had read; but it could not be expected that everything which might be supposed to be even of essential importance to the subject, could be compressed into so short a paper. On one point there seemed to be a little want of unanimity, namely, the uselessness or otherwise of legislation with regard to fisheries. The views on this subject came from two different quarters, and they differed according to the quarter from which they came. Some years ago he had the opportunity of being present when evidence was laid before the Commission which had been referred to, when Mr. Buckland, Mr. Walpole, and Mr. Young went round on the east and west coasts of Scotland, and he found that all those who were interested in the inshore fishing demanded that there should be restrictions, while those who depended

on the system of fishing which was now so successful, namely, employing bigger boats, bigger nets, more of them, and going out sixty, seventy, or a hundred miles to sea, and catching the herrings before they came into the small bays, these came to the conclusion that it was practically useless, if not mischievous, to make such laws as those who had little boats and depended on fishing in the small inland lakes demanded. He was not prepared to say that the gentlemen from Canada were wrong in saying that it would be perhaps dangerous to do away with restrictions there; but it must be borne in mind, that large as the Canadian lakes were, they were different from the Atlantic ocean, and whilst restrictions in Canada might be useful, it did not follow that such restrictions would be of any use when dealing with such a large space of water as the Atlantic. There was just one omission in Mr. Duff's comprehensive paper which he should like to bring under the notice of the many eminent men whom he was glad to see were taking a practical interest in this matter. Hardly any reference was made to the fishing on the west coast of Scotland, a comparatively new enterprise, which was carried on in the open sea. There had been for many years from 1,000 to 2,000 boats engaged in that way, not in the Loch Earne, not in the Firth of Clyde, but out from the outer Hebrides into the Atlantic. They began to get fish there on the 24th of May, and continued up to the present time, and a very large quantity was caught there. The facilities for sending it to market, however, were very bad indeed. One fact would show the extent of that fishing industry. In a Parliamentary paper submitted to the House of Commons not long ago, it appeared that from the railway station at Oban, three times as much fish was despatched as from any other station. Upwards of 12,000

tons of herrings were sent from that station, whilst the total quantity sent on the whole Caledonian railway system, including all the towns from Aberdeen to Montrose, was only about 25,000 tons. He hoped, therefore, that some account would be taken of this newly developed fishery out in the Atlantic, by boats coming from Montrose, Fraserburgh, and all the north-eastern points to Stornoway. There was no telegraphic communication of any kind, and the people were put to a very great inconvenience in consequence of having no facilities for sending their fish to market, or getting salt or anything else when they had a large supply of fish.

Mr. JOHNSON (Montrose) said he was one of the jury to examine the salmon nets and fixed nets, and whilst examining these nets he had been very much interested in the exhibits from foreign countries. For many years they had been fishing with the same nets with very little improvement except, as Mr. Duff had said, that they had substituted cotton for hemp, and had made, what they called in Scotland "clipper nets." The first thing which the jury discussed was the steamer on the Canadian lakes, which had been already referred to. It was the first thing which took his attention and had riveted it ever since, and he had wondered whether it could be adapted for herring fishing. It could be seen in the Canadian department, and was shooting a net over the stern and was hauling one in at the bow at the same time. He did not expect that that would ever be carried out in the herring fishery, but he thought it came nearest to anything he had ever seen for doing what appeared very desirable, viz., having some mechanical means of reeling up the nets. The only difficulty which he saw in the way was in reeling up the herring nets to get clear of the buoys that buoyed it up. So impressed was he with the adaptability of that steamer

that he was quite prepared, with the sanction of the Executive Committee, on behalf of his firm in Montrose, to offer a prize to any one who should adopt that system and make it workable for the east coast herring fishery. The next thing he noticed was the purse seine. He understood that was largely used in America, and he thought if it were brought into use in the herring fishery it would revolutionise the trade to a large extent. If they could get these nets to work on these large steamers they could soon bring them into port. For some years past when the boats had been going longer distances, instead of coming in in twenty-four hours they were sometimes three days; and he recollected on one Sunday morning about £500 worth of herrings had to be carted direct to the manure heap because they had been three days in the boat instead of one. He should also be glad to give a premium in connection with the purse seine if it could be made available for herring fishing. The only other matter he would speak about was a cod net which was entirely new to him but which was exhibited in the Norwegian, Swedish, and Canadian sections. The nets of Norway and Sweden were what would be called gill nets, or hung nets, sinking to the bottom. He had never heard of a cod in Scotland or England being caught in any net except the trawl. He should like, if possible, to bring these three nets and the steamer before the fishermen of the United Kingdom, and would suggest that it would be very valuable if some of the illustrated newspapers would give drawings of the net and as much explanation about them as their friends from those countries would be willing to impart.

Mr. WILMOT (Canadian Commissioner), having heard the Canadian name mentioned conspicuously in regard to a particular description of net, wished to say a word upon it. He was not going to discuss the question of herring

fisheries to any great extent, but merely to state, as he did on a former occasion, that if herrings were caught in such vast numbers as it was proposed to do by these machines it must more or less affect all other fish inshore. The herring was the principal food of a large class of fish, and if they were destroyed to such an extent by these improved machines and all the ingenuity which man could bring to bear, not only would the herring be exterminated, but it would very seriously affect the other fish which fed upon them. He regretted very much to find that the system pursued in Canada was now being taken hold of so readily by gentlemen from Scotland for the destruction of these poor innocent fish. These things were sent over merely to illustrate the mode by which fish were sometimes caught in Canada, and it was being taken hold of to exterminate, to a greater extent than was now done, the class of fish which in Canada they were desirous of protecting. The herring of Canada was a different fish from the herring of the sea; it was a salmonoid very much superior to the herring of the sea, and at one time existed in vast abundance in the inland lakes of Canada. In some of those lakes there were now no herrings left at all, and the consequence was there were no salmon, no salmon trout, and none of the many species of fish which feed on those herrings. If this could be done in a short period of time in the great inland seas of Canada, the same results would follow here if these destructive engines were adopted, and no protection given to the fish. The food of the larger fish must not be destroyed if they were to be retained. The Almighty had made all things wisely; He caused the herring to multiply beyond almost any other fish, because it was fed upon more largely than any other description, consequently the herring must produce a greater number to keep up their kind, and if they went on inventing engines, and using every effort to destroy

the smaller fish simply because he was small, the result would be to exterminate the larger ones. However he would not speak at any length on this subject, because he anticipated it would come up for discussion later. He rose to thank his friends who had thought proper to draw attention to the superior modes of fishing to a certain extent pursued in Canada, and to warn them not to use it very largely, for fear that if they did, they would destroy the vast supplies of herrings in the sea, and as a consequence the larger and better description of fish also.

Earl DUCIE then proposed a vote of thanks to Mr. Duff for the paper he had read, which was very valuable, not only in itself, but for having produced what one of the speakers had called a want of unanimity, which he considered to be one of the most valuable features of the discussion. Mr. Duff had treated of the history of the herring during the present century, but he remembered in the course of the discussion that he had read in Gibbon, who, when treating of one of the early eruptions of the barbarians in the early Christian ages, and describing the effects that it had on Europe, told them that it had even interfered with the herring trade on the coast of the North Sea, and he would commend that remark to the investigation of anybody who proposed to write the history of the herring.

Sir GEORGE CAMPBELL seconded the motion. He said in these days of division of labour, however talented a man might be, he never was so effective as he might be, unless he devoted himself specially to one subject. That was what his friend Mr. Duff had done, and he had done so with good effect. He showed, in his own person, that a good sailor and a good fisherman was likely to make a good member of Her Majesty's Government, and so he was heartily welcomed in the function which he fulfilled in the

House of Commons. He had not only given a deal of useful information, but had given rise to a very interesting discussion. These were days in which Radicals were found attacking our oldest institutions; next to the Bible, he thought nothing was so firmly fixed on the Englishman as the old proverb that there were as good fish in the sea as ever came out of it, but even that had been questioned to-day, and had led to a very lively discussion. He did not pretend to say which side was right; he would only observe, as another speaker had done, that there might be two sides to this question, as regarded the deep sea and the inland waters. His attention was especially called to that from the observation of Mr. Wilmot, from which it appeared that the American herring was totally different from our herrings; but the discussion had been with regard to the European herring, and he thought there was a great deal of weight in the arguments and the facts stated by Mr. Duff.

The motion having been passed unanimously,

Mr. DUFF, M.P., in reply, said he had been very glad to have aroused such an interesting discussion. He would not enter into the question at any length, but he might be permitted to recall to the recollection of the audience a distinction drawn by Professor Huxley in his opening address. He said there were two kinds of fishing, fresh-water fishing and salt-water fishing, and while it could be shown that you could over-fish and destroy fish in fresh water, there was nothing to prove that salt-water fish were exhaustible. This had a bearing on the remarks made by Mr. MacLelan and Mr. Wilmot, because both those gentlemen's observations had reference to the fresh-water fishing and the lake fishing. Dr. Day, who spoke of sea fisheries, did not quite go the length of saying what they were to do. He rather criticised his observations, without putting

forward any alternative scheme. He did not think it was possible for man to destroy the fish in the sea. That point was very shortly and ably put in a lecture which Professor Huxley gave at Norwich. He said there were a number of enemies of the herring: the cod fish, birds, and everything else we have heard of, and if man took so many herrings out of the sea, it was a sort of co-operative society, those others herring fisheries getting so much less; but as for any idea of destroying deep sea fisheries, from the knowledge we possessed he was diametrically opposed to the opinion expressed by Dr. Day and some other gentlemen, and he believed that more investigation would only show that it was absolutely impossible. Still, he admitted it was a subject which ought to be discussed, and he was glad to hear their opinion upon it. He did not think it was possible to supply the markets now by simple inshore fishing, and while he admitted that to some extent those fisheries might be injured, much more harm was done to fisheries in general by trying to protect them, than any good which might be supposed to be effected by increasing the inshore fisheries. It was true that restrictive legislation had not been put in force in all cases, but both the chairman and himself had alluded to the very great mischief which was done on the west coast of Scotland, for the population of the western islands were reduced almost to starvation by laws which did absolutely no good to the fisheries. The Executive Committee would pay every attention to the suggestion made by Mr. Johnson with reference to bringing the matters he mentioned more fully before the public. In conclusion, he begged to propose a vote of thanks to the Chairman, who, he was glad to think, as a scientific authority, as well as a man of practical knowledge, entirely agreed with him on the controverted question which had been raised.

Mr. BRUCE, M.P., seconded the motion. Having the honour to represent in the House of Commons a number of fishermen located on the shores of the Firth of Forth, he had naturally listened with great interest to the discussion, and he might say that was one of those places where the herring fishing used to be prosecuted with greater success, but which appeared to some extent to have been deserted of late years by the herrings. The reasons for this were not very well known, but he was glad to say that the fishermen in that quarter had not given up fishing, but had improved their boats and gone farther out to sea to carry on their industry. Whatever else they might differ about, all would agree that it was of the greatest importance that a gentleman of such ability as Sir Lyon Playfair should give his mind to the study of these subjects, and that nothing but good could result from his investigations.

Mr. WILMOT asked leave to add, in explanation, that the salt-water herring fisheries were more extensive than the whole of those on the shores of Great Britain, and that whilst he spoke of the fresh-water lakes Mr. MacLelan had spoken of the herrings of the sea.

The vote of thanks having been carried unanimously,

The CHAIRMAN, in responding, assured Dr. Day that the last thing he desired was to stop discussion by speaking *ex cathedrâ*, but, as late Chairman of the House of Commons, he knew that having spoken then he could not speak again, and so was obliged to say all he had to say; but it was with the desire of eliciting discussion, and not putting an end to it. He had been delighted to hear the different opinions given by different speakers, and he was quite sure the public would profit very much by the different views put forward.

MACKEREL AND PILCHARD FISHERIES.

BY

THOMAS CORNISH.

CONTENTS.

CONFERENCE ON 13TH JULY, 1883.

Sir JOHN ST. AUBYN, Bart., M.P., in the Chair.

THE CHAIRMAN, in introducing Mr. Cornish, said he had come at the request of the Executive Committee to tell them something about a subject on which most people knew comparatively little. Whilst almost everybody in the room was more or less intimately acquainted with the mackerel, there were very few, except those who lived in Cornwall, on the west coast of Ireland, and on the coast of Brittany, who knew anything about the pilchard; but they might take it on his authority that the pilchard was a most excellent fish when eaten fresh, and when preserved, either after the manner of sardines in oil, or salted for exportation, it formed a most nutritious and excellent article of diet. The Cornish fishermen were employed to a very large extent both in the mackerel and pilchard fisheries, and went out a considerable distance from the shore in quest of these fish. They met with the mackerel at spring-time at a distance varying from close in-shore, to sixty, seventy, or one hundred miles out, and twenty-four hours after they were caught, people in London were in a position to judge of the result by seeing the mackerel on the slabs of fishmongers. A pilchard was a different sort

of fish altogether. It did not readily bear carriage, but had to be eaten as soon as possible after it was out of the water, and consequently the great trade in pilchards was when they were salted or preserved in oil. He could not give the statistics of the men, boats, and capital employed, but, to give some idea of the magnitude of the fisheries, he might mention that, in his own immediate neighbourhood, the water on which he could look down from his own windows contained within two and a half miles a fleet of something like four hundred boats, with all kinds of nets and gear and other appliances, representing a capital of something like £140,000. If a proportional amount of capital and men were employed in other parts of the country, it could readily be seen how important those fisheries were. They were not only important as a means of providing food, but formed an excellent nursery and school for a race of seamen than whom there were none, either in this kingdom or anywhere else in Europe, more industrious, steady, independent or courageous.

MACKEREL AND PILCHARD FISHERIES.

The honour has been done me of requesting me to read a Paper before you on the "Mackerel and the Pilchard," and I presume that this has been done, because I come from West Cornwall, the principal English home of the fisheries for these two fish, and am well acquainted with them; but my ignorance makes it advisable that I should confine my remarks to the familiar facts which I know of these fish in my own county, rather than attempt to deal with the subject scientifically.

The mackerel is the head, or typical fish, but one of the smallest in size, of a large family, which has representatives in every sea in the world, except in the regions of extreme cold, and every member of which is excellent as food.

The first distinguishing mark of the family to an outside observer is a tail having a peculiar fork. You can see it in a moment in the fish market here. The next is the cleanness of the lines on which the fish is built. The long conical forepart of the body and snout, the smooth round body, and the clean run of the afterpart, all fit the fish for rapid propulsion through the water, whilst the powerful forked tail, working with much less opposition to the water than would a rounded tail, and precisely with the action with which the sailor sculls his boat by one oar over the stern, enables the fish to make the greatest possible use of the advantages of its shape. The last distinguishing exterior feature which I shall notice is the existence between the base of the tail fin, and the hindmost upper and under fins, and both above and below the body, of a series of little soft rudimentary fins, called finlets, and the use of which is obscure. This family includes the bonitos, the tunnies, the albacores, and other Mediterranean fish, all occasional visitants of our Western seas, and just excludes (if, indeed, it does exclude, for I, who have seen the fish, am not clear about it,) the Northern "opah," a noble great fellow, some four to five feet long, which would more than cover an ordinary card-table, and is a very Assyrian for "gleaming in purple and gold," being in fact almost the only northern fish which excels in splendour of colour the fish of the seas of the temperate zones and the tropics. I do not at this moment recollect whether there is a specimen of this fish in the building. If there is, you will find it in the court of Norway or possibly of Denmark.

But, of all the family, the mackerel is the most fitted for rapid propulsion and has the most powerful tail; and this, you know, means the greatest power of propulsion, for the sole natural propulsive power of every fish lies in its tail. I once proved this beyond question, thus:—We stay in summer in a house so close to the sea that we are in our boat within a minute of our leaving our front door, and we have there a pill, or salt water pool, in the rocks, about thirty feet long by ten wide by three deep, which is left by the tide for about six hours in every tide, and into this pool we put the fish which we bring in alive from our trammels every morning, and watch them until we want them.

I have watched an octopus in that pool many times. But once I cut off the tail of a fish, a pollock I think, and I put it in this pool. At first the fish did not realise its loss, and we saw the stump of its tail working, but the other fins were, as usual, only balancing the fish. There was no progression. After a while the fish stopped working the stump of the tail, and lay simply balanced. About an hour afterwards I came back to it, and it was slowly progressing by using its pectoral fins (those next behind the gills) as oars. I had seen all I wanted to know, and had ascertained that the tail fin was the fin of propulsion, that the fish had sense enough to find out when it had lost it, and reason enough to adapt its pectoral fins to a use for which they were never intended. I then killed the fish, but my conscience did not, nor does it, accuse me of any cruelty towards it. It showed no symptoms of pain. Indeed, of all the very many thousands of fish that I have seen die, I never saw one show symptoms of pain. The nearest approach to it has occurred in the crimping of skate immediately on its being taken out of the water. The crimping is done by drawing a sharp knife in three cuts to the bone, on each side of and parallel

to the back-bone. The fish writhes under the knife, but from muscular action, I think, more than from pain, and before the last cut is given it is dead. And this, in my opinion, is a much more merciful way of dealing with the skate, than allowing it to lie suffocating in the bottom of your boat for the hour which it occupies in dying that way. I know many good people say that we should kill our fish as we catch them. If we could, we would, for they would be so much the better for the table, but in most kinds of sea fishing this is utterly impossible. Take a mackerel seine for instance. A tolerably successful haul ought to produce at least 2,000 fish. After the haul commences, everything depends on the speed with which it is completed. Every hand on board the boat is at it, and in a few minutes the 2,000 fish are spluttering about in the bottom of the boat. I once took upwards of 6 cwt. of fish, principally skate, on a long line of 500 hooks (i.e. 500 fathoms) stretched along the bottom of the sea in shallow water, in one haul. The whole hauling had to be done with the least possible stoppage, and at times the fish came so fast, that the boatmen attending on me had not time to unhook them, and had to cut away the snoodings. The fish had to lie in the bottom of the boat and die, we could not stop to kill them. And in the end I found that the line had cut my two forefingers almost to the bone. The fish were crueller to me that day than I was to the fish.

Whether viewed for its colour or its form, the mackerel is one of the most beautiful of English fish. I need not describe it to you. Doubtless its form is familiar to you all. And if it is not you have only to go into the fish-market here and see it in as much perfection as it can retain after a long journey. Beautiful as the mackerel on a London fishmonger's stall is, much more beautiful is it as it

comes out of the water alive. There is, in the best mackerel, an iridescent, rosy tint under the gills and forepart of the body, which I have seen in fish here, but which is much more conspicuous when they are taken. And it is this colour by which our fishermen judge their fish. They say, "*Red* mackerel is *good* mackerel; *white* mackerel is mackerel; *green* mackerel is poison."

And in this last remark they are quite correct. Whenever a green hue supersedes the rosy, the flesh of the fish when eaten will, with very many people, produce most unpleasant symptoms of blood poisoning; and as these green mackerel are taken amongst the others at all times of the year, they give the fish a bad name, and cause people to abuse the whole family, when the truth is that they ought to have made a better selection.

An average mackerel weighs 1½ lbs., which gives about 1,500 fish to the ton. Large fish go to 2 lbs. or even 2½ lbs. but they are rare, and as they do not sell for more than the others, are reserved by the fishermen for presents to their friends, which starts another of our West Cornwall notions that "you should never eat a mackerel unless it is given to you." This saying is quite understood in West Cornwall now, but in process of time it will very probably get to be understood there, as meaning that it is unlucky to *buy* mackerel, and if that belief once gets about, well, we are a superstitious people, and you ladies and gentlemen in London will have a large addition to your supply of that fish from Cornwall.

These large mackerel are usually females, with roes ready to be shed, and are known as *Queen* mackerel and *King* mackerel, but I do not recollect ever seeing a large male mackerel of this sort.

Sometimes one is startled by an announcement in the

papers that a mackerel of six or even eight pounds weight has been caught, but in every instance in which I have been able to make inquiries the fish has turned out to belong to an allied species—the short finned tunny—which sometimes herds with the mackerel.

There is one fact about the personal history of this fish, which I will mention although I know I do it at the risk of having my veracity suspected; but I narrate only what I have seen over and over again, have repeatedly shown to my friends, and am prepared to show in the cases of two fish out of three, to any one of you who will call on me at Penzance and go out and catch mackerel with me. The mackerel, like the turbot, requires, and has, enormous muscular power at the tail to give the tail-fin its full advantages. In the turbot the fishermen recognise this fact and say that the turbot has a "second heart," and, as soon as they can, after they have caught one, they, at least in our parts, "bleed it," that is, make an incision on the line of the lateral line on the white near the tail, which cuts into this "second heart," and from which the fish bleeds freely. They have an impression that it whitens the white. Now, for my mackerel. The strongest and most muscular fish are those which wander about by themselves, and take surface bait, and it is on these only that my experiment has been tried. Take one of these immediately it comes into your boat, and, at once, without injuring it more than is necessary, prepare it for the gridiron just as your cook would, and lay it on the deck of the boat. In a short time a muscular action will develop itself in the tail, and the disembowelled fish will turn a clear summersault, sometimes two, and occasionally three, and will then become quiet after a convulsion in which every fin vibrates. Like many other discoveries this one was made by accident; but I

call your attention to the fact that very much the same sort of thing happens in the case of a common snake killed, and dead beyond all question, but in which a muscular action goes on for hours, and gives rise to the common idea that a snake never dies until sunset. And I think our medical men can tell us that a very strong muscular action occasionally takes place in the human body after death from some particular convulsive diseases.

Taking the season through, a mackerel is worth two pence at the boat's side, and, with that fact before you, I leave you to judge how much the railway carrier and the fishmonger between them get out of the consumer.

Of course the price varies from day to day. Within the last month I have known mackerel selling at the boat's side for two and six pence per one hundred and twenty, or just one farthing per fish; and a boat with a catch of eight hundred threw them all overboard rather than come into harbour and pay her quay dues. On the other hand I have seen them selling at the boat's side at one shilling per fish.

The mackerel fishery of Cornwall is a very old one. The fish itself was known in our seas very long ago, for it has a name in the old Cornish language ("brithel"), but it was but a small affair until railways opened up our markets in 1859. I find that in 1808 we were sending mackerel from Penzance to Portsmouth in sailing cutters, but the record does not say in what condition they arrived there. It was probably fortunate for their owners that there were no Sanitary Inspectors about the markets in those days.

At this time, the fleet employed on the fishery in Cornwall consists of about 400 sails of luggers of about 15 to 18 tons burden, excellent sea-boats (of which many models are to be seen on the Cornwall stall in the British Fisheries Gallery), costing, when the nets are on board, six hundred pounds

each. They are capable of going closer to the wind than any ordinary yacht. The spread of canvas they make is, as you can see for yourselves, enormous, and they will live in exceedingly heavy weather; but they give in sometimes. Three years ago the boat *Jane* succumbed to a fearful cross sea, and sank within two hundred yards (one hundred fathoms) of Penzance pierhead, and drowned her crew of six men and a boy, not only within sight of their own homes, but within sight of their wives and children, who knew what boat she was. But even in that case, the men who knew said she was lost because she had not sufficient canvas on her to force her through the sea.

If one of these boats is overpowered by the sea, she takes down her spars and makes them and her nets and such of her sails as she can afford to risk into a kind of raft, under the slight shelter of which she rides out the gale; but you will find on the "Cornwall Stall" a suggestion for a very great improvement in this method. The exhibitor is a Cornishman, and he calls it a "floating anchor." It consists of a beam of timber to which is attached a large square piece of canvas, to which is attached another beam of timber from which there trails away a perforated zinc can which finds its place, when at work, in the cavity of a cone made of canvas, fastened to a wooden hoop. When the boat is storm-pressed she lowers her masts, heads up to wind, and hoists the whole machine out ahead of her and makes fast to the first beam; and then, being deeper in the water than the machine, she drifts astern and down the wind towing the anchor, the outer beam of the anchor stretches the canvas sheet, and is assisted in doing this by the cone which it is dragging mouth foremost. The cone meanwhile is receiving from the zinc can, oil which exudes from it, and which the cone itself sends

out in a fan shape. Thus, an advancing wave first meets the oil, of the effect of which we have heard so much lately. It then meets, and perhaps breaks against the forward beam, and then has to pass under or fall on the sheet and in any case will reach the boat in a very enfeebled condition. I find practical men are speaking very well of this invention.

Each of our boats carries a crew of seven men and a boy (the latter usually a relative of one of the crew), and is owned by a practical fisherman—very frequently by the master or his father—and is worked on the share system, under which each man brings a certain number of nets on board, and the proceeds of each season are shared in a peculiar and complicated way between the boats, the crew, and the nets. We have no large boat-owners and no boat-owning companies. This state of affairs produces results which, like many other things in Cornwall, are peculiar to the county. When the Commissioners came down last year on the inquiry as to—

Cruelty to fisherboys.

The prevention of desertion, and

The method of paying wages.

we satisfied them that under our system there was, in our fisheries :—

No cruelty to fisherboys.

No desertion—self-interest preventing it.

No disputes as to wages.

This last thing puzzled the Commissioners most of all. After the meeting two fishermen and myself were standing in the lobby when the Chairman came to us and said :—

"I am satisfied you have no disputes about wages, but I cannot make out how it is done." And I turned to one of

the fishermen and said, "Tell the gentleman how it is done," and he said, "We leave all that to the women."

It will be seen from the numbers which I have given, that our mackerel fishery gives employment to about 3,000 men and boys, who, between the month of February when the season begins and June when it ends, usually catch about 4,000 tons of fish, which will give six millions of individuals. As soon as our mackerel season is over the pilchard season begins, and when it ends, our fleet sails for the Irish fishery, the Plymouth fishery, or the East coast of England fisheries; for they can go anywhere. One once reached Australia safely, but now, in these days when 14 foot punts cross the Atlantic, that is no great feat.

Still, in 1854, when the *Mystery*, of 36 foot keel and about 15 tons burden made her voyage, no boat of her size had ever attempted to deal with the Atlantic Ocean since the Caravel, which was the smallest of the little fleet of Columbus, had done so 350 years before, and she was in company with large vessels, and therefore the voyage of the *Mystery* remains noteworthy. This solitary boat sailed from Mount's Bay on the 18th November, 1854, and reached Melbourne on the 14th March 1855, after a voyage of 117 days. She had a crew of seven men and carried her nets. I have recovered the log which was kept on board of her,* and, judging from it, a more dreary voyage than hers was never made. Beyond sighting a few ships and a few albatrosses, and being fêted at Table Bay, nothing seems to have occurred of more importance than "the broaching of the second barrel of pork," until they were nearing Australia, and then, for a short time, things got exciting, and they met with weather which made them ride

* Kindly lent to me by Mrs. Boase, the widow of the seaman who kept it.

to a raft in the way which I have described, and which they describe.

Thus, on 18th February, 1855, the Log says :—

Sunday, February 18th, 1855.

Lat. by acct. 40° 5′ S. ; Long. 81° 25′ E.

A.M. Strong gales with heavy sea running.

4 A.M. Gale still increasing, handed the foresail and set a reef second mizzen forward.

6 „ Terrific gale with a tremendous heavy sea running, and carried away the second mizzen yard. Brought the ship head to wind and hove a raft out.

6·30 A.M. Split the third mizzen, unbent it, and bent the new one.

8 „ Gale still increasing, with more sea and heavy rain.

NOON. Ditto, weather.

3 P.M. Less wind and sea, made sail, set reef second mizzen forward.

MIDNIGHT. Strong squally weather.

Friday, February 23rd, 1855.

2 P.M. Gale fast increasing.

4 „ A complete hurricane, with mountains of sea and very heavy rain. Brought the ship head to wind. Ship riding very easy to a raft prepared for the purpose.

7 „ Rather less wind. Veering to the westward, hauled the raft on board, made sail, set reef second mizzen forward.

Saturday, February 24th, 1855.

A.M. Strong winds with a heavy sea on.

4 „ Moderating, set storm foresail and jib ; squared.

8 P.M. Light airs and cloudy, all possible sail set.

10 „ Heavy rain. Wind inclined northerly.

NOON. Jibed ship. Lat. by acct. 40° S.; Long. by acct. 101° E.

P.M. Wind veering all round the compass, with heavy showers of snow and sleet.

3 P.M. Set the jib.

4 „ More wind, took in the large sails and set storm foresail and third mizzen.

5 „ Heavy gusts of wind and rain, ship running under bare poles.

6 „ Set reef second mizzen forward.

7 „ Very heavy squalls. Hauled down second mizzen.

8 „ Set second mizzen.

10 „ Down sail.

11 „ Set it again.

MIDNIGHT. Very strong squally weather.

Monday, March 5th, 1855.

AM. Strong gale, with mountains of sea. Ship running under reef second mizzen forward. Shipping a great quantity of water on deck.

4 P.M. Gale increasing with a great deal more sea.

6 P.M. Complete hurricane. Brought the ship head to wind, riding very easy, raft prepared for the purpose.

MIDNIGHT. Very heavy weather, with a high sea running.

Tuesday, 6th March, 1855.

A.M. A terrific gale of wind, it being the heaviest that we have experienced since leaving England. Our gallant little boat rides the mountains of sea remarkably well, not shipping any water whatever, having dry decks fore and aft. I am confident that she is

making better weather at present than a great many ships would if here.

4 A.M. Heavy gust of wind.

8 „ More moderate.

9 „ Hauled the raft on board, made sail, set reef second mizzen forward.

NOON. Very strong weather. Lat. by observation, 40° S. Long. by chronometer, 131° E.

Saturday, 10th March, 1855.

A.M. Very heavy gale with a high sea running, ship riding very easy to a raft.

8 A.M. Ditto Weather; repairing the second mizzen.

NOON. Rather less wind and sea. Lat. by observation, 38° 39′ S.; Long. by chronometer, 140° 45′ E.

6 P.M. Hauled the raft on board; made sail, set storm sails.

10 „ Moderating fast.

11 „ Made the Australian land between Cape Northumberland and Cape Bridgwater. Tacked ship. Wind off the shore.

MIDNIGHT. Very fine weather.

The log does not state her rate of sailing, but I learn from Mr. J. C. James, who is related to one of the crew, that during one period of twenty-four consecutive hours she made eight knots, which is the equivalent of something like nine and a half miles per hour.

Our men, when on the home mackerel fishery, sell their fish to buyers—who are sent down by the large London and other houses for the purpose—in a very primitive but very effective fashion. The auctioneer takes his station on the beach in the early morning with the buyers around him.

A boat appears in the offing, and signals her number and the number of fish she has. The auctioneer announces both, and, if the bidding is slack, chucks a stone into the air. The buyers have to bid before that stone falls. If a bid comes, another stone is chucked up, and so on. And as the boats do not all arrive at the same time, this method conduces to much speculation.

Sometimes the fleet puts into Scilly, and sends the catch to the mainland by steamer. Then the market is steadier, because the total of the catch is known by telegraph ; but scenes of wild excitement take place. The early boats unload and pack their fish and stow the baskets on board the steamer, but the late boats crowd round the steamer, which is a mail boat and bound to time, and simply unload their fish on to her decks. These fish are packed on the way over by men working against time. I came over in the steamer once when she had more than 60,000 fish on board, and I watched the packing of more than 15,000 of them, which had been thrown loose upon her deck, after which I considered I could say that I knew mackerel when I saw it. It was on a hot summer's day, and as the steamer rolled to the Land's End seas, the packers were constantly ankle-deep in blood and slush.

One result of this investigation was the certain conclusion that the "scribbled mackerel" and "dotted mackerel" of Couch (British Fishes) were only accidental varieties of the common mackerel.

Strictly speaking the mackerel is not a migratory fish. It is in our seas all the year round, but in the season which I have mentioned—February to June—it, for some unknown purpose, crowds from the deep sea inshore. By day, during this season, it swims in scools or shoals, and by night it makes a formation in loose order, probably for the purpose

of feeding; but it never pursues, as true migrants do, any settled route. The fishermen have to search for their fish day by day. In the day-time the fish are taken by the scool or shoal in shallow water by the seine net, a net shot ahead of and around them. In the night-time they are taken by the drift-net, a net shot over the boat's side, and fastened at one end to the drifting boat, which goes with the wind or tide or both as may happen. The fleet represents a capital of about £240,000, the property of *bonâ fide* fishermen, and certainly deserves the protection which it requires. The drifters are much put upon by trawlers. These latter drive in hours which belong to the former. Trawling is a day fishery; driving is a night fishery, and every now and then the slow moving, helpless, illegally fishing trawler comes across the nets of the equally helpless but legally fishing driver and carries them away. This happens in the night time; the driver never has a punt with her and cannot ascertain the trawler's number. In fact she does not know that the mischief is done until she hauls her nets, and she has no remedy. I have known £400 of damage done to the drivers in this way in a single week. The thing could be easily prevented; a gunboat or even a Government cutter cruising on the fishing-ground during the two months in Spring in which the mischief happens, would stop the whole thing. Some years since we had reasons for expecting to see that gunboat come round the Lizard every day for three seasons in succession, but she never came, and we gave up expecting her.

There is another matter in connection with our Mount's Bay fleet, and I believe it affects also some of the other fleets, which I think may interest you. Just before the *Jane*, of which I spoke just now, was lost, a Mutual Fishing Boat Insurance Club was started for the Mount's

Bay fleet. But we had then lost no boats lately, and our men were indifferent about it, and the thing fell flat. Only seven boats were entered in it. It happened that the *Jane*, and two other boats, partially wrecked in the same storm, were in it, and the club was ruined. The public generously gave us over £2,000 to provide for the widows and orphans of the crew of the *Jane*, and to repair damages generally. Out of this fund we provided liberally for the widows and orphans, and we then paid to the club enough to enable it to meet the demands on it, and we then distributed the remainder of the fund amongst the other owners whose boats had sustained damage, with the distinct assurance that if they did not put their boats in the club no one would ever again stir a finger to help them in case of accident. The Cornish fisherman is not behindhand in taking a hint, and I believe every boat in the bay is now in the club, even before she is launched. I certainly do not wish to see any club make its prosperity by such a fearful experience as that which set up ours, but I shall be most happy to send the rules of the club to any one, interested in the matter. The general outline is just this: nets are not insurable (for want of that gunboat.) The surveyor of the club examines each boat entered and reports on her value, and she is then insured in two-thirds of her survey value. Losses are made good by the levy of a rate on all owners of boats in the club at the time of the loss, and no loss is made good which is occasioned by any neglect to observe the Board of Trade Rules.

I wish to call your attention to a great advantage which this Exhibition will certainly confer on Cornwall. Mackerel shoal in deep water as well as in shallow. Our desideratum for a long time past has been a seine which can capture the deep water shoals. A gentleman named Cox, a Cornishman,

has invented a seine of which a model is in the middle of our Cornwall stall (it is the one which has the weight attached to it), which he says can be worked at deep sea shoals of fish; and curiously enough, a model of a second seine on the same principle, but differing a little in detail, is exhibited on the same stall by Mr. Moses Dunn, of Fowey, and a third by Mr. Barron of Mevagissey. Practical men saw these models, both before they came here and since, and pronounced them very pretty little toys, which might succeed in a fish pond, but utterly unfit for use at sea. Now a full seine costs a large sum of money, and no hard-headed capitalist is likely to lay it out on a speculation which the practical men tell him must fail. Well, the nets come here, and to them came an American gentleman and he said, "You have the precise principle on which we are working deep-sea seines in America, and they succeed admirably."

There is another point which I must not overlook. There is an idea of great antiquity, and very generally entertained, that mackerel must always be fresh to be good. It is perfectly true that mackerel is in its perfection when cooked as soon as captured, but if that cannot be done it is like most other fish, none the worse for a little keeping. And it is for this reason, and because ice takes the flavour out of the fish that I consider dry packing (ie., packing fish-upon-fish without ice) preferable to packing in ice; it injures the flavour less. But there is another view to be taken. This fish is eminently amenable to the action of antiseptics. The smallness and fineness of its scale causes an antiseptic bath to act upon its skin and gilled surfaces with marked effect. I once received two of the large mackerel of which I have spoken, which had been caught off the Scilly Isles on a Monday night in the month of June (I believe, at all

events in the height of summer); I received them in their natural state on Tuesday evening, and put them into a bath formed by the solution of some antiseptic in powder, which the late Mr. Frank Buckland had procured for me. The bath totally destroyed the beauty of colours of the fish, and turned them into a dirty brown, but I ate one of those fish on the Saturday after in perfectly good condition and flavour, and I could have eaten the other in the same state, so far as the flesh went, on the Saturday after that again, but the flies had got at the gills, and the idea was distasteful. I wrote for some more of the disinfectant, and the reply that I got was that the company was in liquidation, and that I could have the patent for £1,000; so I thought no more of the matter and have forgotten the name of the disinfectant. I only mention the matter to show of what service antiseptics may be.

The drift fishery of which I have been speaking is the principal mackerel fishery now, and supplies us with practically the whole of this fish. The few thousand mackerel taken at present each year in seines are wholly absorbed in strictly local markets. The mackerel takes bait, but, generally speaking, shyly. Every five or six years they turn up in large shoals, which are intensely localised, in the autumn and for about two hours a day, in the evening, for a week or ten days, take surface bait greedily. I, myself, once cruising backwards and forwards over a little patch of ground (where a shoal of this sort had located itself), for about two hours between five and eight on each evening, for four days in August month, took, on a whiffing or light hand-line and on a hook baited with a strip cut from an old white kid glove, over three hundred fish. I have known the mackerel to be in shoals in December, but this is rare. When they do occur in

that month they are small but in excellent condition as food.

Before I pass away from the mackerel, on which I have detained you a great deal too long, I wish to tell you of another discovery of mine, which no doubt equally affects all fish ; but as my observation of it was made on mackerel, I confine my narrative to that fish. Its habit of shoaling in the daytime taught me the curious fact that the shoal leaves behind it a distinct scent in the water, and that there are other inhabitants of the sea who quite understand what that scent means, and utilize it.

A shoal of fish in the water looks, at a distance, like the shadow of a cloud moving steadily on. As the shade nears you, you can see the fish "playing," jumping out of the water just as small trout do, only in a large shoal you will see thousands of fish out of the water at the same time. Each sort of fish gives a colour to the water which is peculiar to it, so that an experienced fisherman knows at sight whether the shadow of the cloud, which he knows to be a shoal of fish, covers mackerel, or pilchard, or herring, or sprat. I was once standing on the beach with an old fisherman when we saw a straggling shoal of fish about half-a-mile long, swimming very slowly, which we could not make out. Their colour was new to him. So we took a boat and went out to them, and found they were a shoal of huge jelly fish, great transparent things shaped like an open umbrella and about its size, having around the edge of the umbrella a beautiful purple fringe which causes you to recollect it if you incautiously touch it. On the occasion to which I refer I was standing on a headland in a place called Prussia Cove, in Mount's Bay, when I saw a shoal, which I knew at once to be of mackerel, come out of a sandy bay there and go due west.

Shortly after I saw a shoal of porpoises (a cetacean which loves the mackerel in an epicurean sense) come lumbering up from the south into the sand. When they came across the trail of the mackerel these latter were a good mile off on their way. The porpoises had no sooner got into their back water than they wheeled into their course and set off in full chase. In about three minutes they were in the midst of the mackerel, playing havoc, whilst the unfortunate mackerel were driving forward in one solid line of terror, making the water foam before them as they fled.

Of the Pilchard I have a different tale to tell. It is a little fish of the "herring" family, generally about ten inches long, and rarely so much as half a pound in weight. It is very local in its habits, rarely occurring in numbers of any importance east of the Start Point, in Devonshire, on the South coast, and Trevose Head, in Cornwall, on the north. It is taken yearly as far east as the estuary of the Exe, and has been taken, and occasionally in large numbers, off Seaton, in Devonshire, at the mouth of the river Axe. Some years since a small shoal was taken off Folkestone.*

It occurs in very large numbers off the south-west coast of Ireland, but there is no native fishery for it there, and as its season on that coast coincides with its season on ours, our people are too busy at home to look after it. It occurs, of course, off the French coasts as the sardine. And the Spaniards have a mode of curing it which altogether beats our English method, as may be seen by a comparison of our

* There is also some record of the capture of a shoal at Harwich, and a fish supposed to be the pilchard occurs in Scotland under the name of the garvie herring, but practically its home in England is in Cornwall and mainly in West Cornwall.

cured pilchards in this exhibition with those in the Spanish division.*

Unlike the mackerel, the pilchard is not sought for in its fresh state out of Cornwall and West Devon. Our fishermen have tried many markets with it, but without success. And this is the more remarkable seeing that the fish is cheap, nutritious, and of exceedingly good flavour. When tourists first found out West Cornwall, they very soon found out pilchards, and more, they turned a little bit of "chaff" against us west countrymen into a reality, at their own expense. It used to be said of us that we ate "cream with our pilchards," which of course we never did. But when the tourist came down, he took it for granted that he could eat clotted cream with everything, and he insisted on having "cream with his pilchard," and he is said to have got it, and to have found it so good a mixture that now no large hotel gives broiled pilchard for breakfast without it.†

But we have other ways of cooking them besides broiling. We fry them and eat them with a sauce made of finely chopped onions, salt, cold water, and nothing else; it is a very nasty sauce. And we eat them without any knives or forks, with our fingers. I do not say that *all* of us do this, but I have seen it done, and less than one hundred years ago the practice was universal amongst the bulk of our people.

I hope to cure this want of a fresh pilchard market soon

* There are two open barrels of the fish exhibited one at each end of the westernmost case in the Spanish Court. One is labelled "pressed sardines," and the other "salted sardines," but they are both of them pilchards, more cleanly cured than is our wont.

† I can speak to the excellency of clotted cream as a sauce with broiled pilchard from personal experience.

in this building. I hope to induce some of our fisher people to send a supply to the fish-market here so soon as the season opens, which it will in a few weeks, and I think that with the great advantages offered here, we may succeed where others, under less favourable circumstances, have failed. Spain is running us so close in the business of supplying salted pilchards for the markets of the Roman Catholic countries, that we could easily find thirty to forty millions of fish for the supply of a fresh fish market without feeling the loss of them. This apparently enormous number would be a mere flea-bite out of our catch for a season. It would be a day's, or at most two day's successful fishing for the seines of St. Ives alone. And this brings me to the support of Professor Huxley in his remark, that in the waters frequented by the pilchard the sea, taken acre for acre, is of greater pecuniary value than the land. A seine when "shot" around a shoal of pilchards may enclose an acre of superficial water, certainly not more than two. It is on record that the seines in St. Ives Bay did on one occasion, in one day, capture 10,000 hogsheads, or over 30 millions of pilchards, worth, over the boat's side, £2 per hogshead. I do not know the number of seines employed, but they could not possibly have exceeded 20; but, supposing they were 20, then 20 acres, or at the highest figure 40 acres of sea yielded £20,000 as its produce for one day, and each season consists of many days, and the fisherman pays no rent.*

* The greatest recorded catch by one seine at one shot was made at St. Ives in 1868. There 5,600 hogsheads, or over 16 millions of pilchards, were saved out of one seine. This catch was worth between £11,000 and £12,000. Remarks of precisely the same character, but differing in detail, apply to our trawling grounds, but as pilchards are never taken by the trawler, I only allude to this fact.

Since I wrote the above about opening up a cheap market for small dainty fish like the pilchard, the question, as one intended to benefit the poorer classes, has been placed before me in what is to me an entirely new light. And it is this: Supposing you can supply pilchards in the height of their season at one penny each over the fish-stall (and the remark applies to all other fish which could be sold cheap), what is the poor man to do with it? In summer he must go to the expense of a fire to cook it. At any time he must provide fat in which to fry it, most of which will be wasted, and after all, the chances are that his wife does not know how to cook it, and will spoil the dish in the doing of it. And for this, my practical informant says, there is but one remedy. If you want to introduce cheap fish for the use of the artisan you must in some way or other start shops or whatever places you like where he can get it cooked. Most of these difficulties apply also to the dressing of fish by boiling, but my informant adds to these another, that the prejudice against boiled fish is at present so deep-seated as to be practically ineradicable.

You will find in this building, pilchards cured by all the methods in use, salted in barrels for the foreign market, dressed in oil, as sardines, or in salt sauce, as anchovies, or marinated, which is, I believe, an invention of our own; and in every form you will find them good.

The method in which the pilchards are cured for the Italian market expresses from them when "in bulk" (i.e., under the pressure in large masses necessary for salting them) large quantities of blood, which run from the curing-house down the streets in gutters to the sea. We are a toast-drinking people, and this peculiarity in the curing process gave rise to a toast which used to be given as equivalent to prosperity to the pilchard fishery. It was:—

"Long life to the Pope, and may our streets run with blood."

The fish itself resembles a small silvery herring having large scales. The people who catch it are much the same as those who fish for mackerel, but the fishery has a separate capital invested in it, the boats and nets used being peculiar to it.

It is captured in much the same way as the mackerel is. In the night in drift nets; in the day time in seines. Originally pilchard seining and mackerel seining were conducted in much the same way, but the decline of mackerel seining has now-a-days caused them to differ.

The lookout of a mackerel seine is mostly kept on board the boat itself, and the seine net is hauled bodily on board with the fish in it, but in pilchard seining the lookout is kept from some hill where the huer—or man stationed to watch for the shoals of fish—can be seen from the boat, standing clear out against the sky. He thus gets a much wider outlook than can be had from the boat. He holds in each hand a bush, and when he sights a shoal of fish he informs the boat of its whereabouts by preconcerted signals made with these bushes. The seine boat moves in the direction indicated, and if it reaches the shoal in time it shoots its net. You must consider of this net when shot, as a round room in the water without a floor or ceiling, and if the shot is successful it contains the pilchards. At the next low water time a net, called a tuck net, and which I will liken to a perforated pocket handkerchief, is let down from large boats stationed at one side of the room of water, the tuck-net being inside the seine, and it is drawn up by means of ropes hauled in on board large boats stationed for the purpose at the other side so as to scoop up the fish in the seine. As the ropes come home the boats close in

upon the net, and then a very exciting, and on moonlight nights a very beautiful scene sets in. Millions of silvery little fish are sputtering and clattering on the surface of the water in the tuck-net. Half a dozen men are in the midst of them up to their knees in fish, handing them into the boats in baskets, and working for dear life. Everybody is giving orders at the top of his voice about everything, and nobody is obeying anybody, and so the work goes on until the coming tide stops them, and causes them to run the risk of the escape of the fish before the next low water. Most of the fish thus caught are salted for export, but many find their way through the locality of their capture in the cowels or baskets exhibited on our Cornwall stall, and which are worn in the picturesque way shown in the lithograph also exhibited there. A strong woman can carry 1 cwt. of fish in the way shown, and for miles.

But the waving of a huer's bushes has a very curious effect on any fishing village which happens to get sight, or news of it. ' To the stranger it would appear that the whole population of the place had suddenly gone lunatic. Every available man, woman and child turns out and rushes violently down the steep cliff to the sea shouting "heva! heva!" Whence the word is derived, we do not know; but it is the signal that shoaling fish are in sight, and that the population must turn out to be ready to receive them, for all this fish-work requires to be done with the utmost dispatch.

A very curious thing, and entirely inexplicable, about these shoaling pilchards, is that at uncertain periods they shift their course for years together. For instance, fifty years ago, St. Ives on our North coast had almost a monopoly of the shoaling pilchard; now she divides with

Newquay. Thirty-five years ago the principal South coast seining fishery was in Mount's Bay, now it is at Mevagissey, and it is no question of new seine fisheries having been established. It is due solely and entirely to a change of habitat on the part of the fish. We have many things yet to learn about the pilchard.

One thing I have learned since I began to write this paper, is that during the mackerel season (February to June) and before our pilchard season commences, numerous shoals of very large pilchards are met with by our mackerel drivers in the deep sea, eight leagues and over, south and west of the Scilly Islands. These large pilchards are mostly females full of roe, ready to be shed, and unlike most fish in that condition are so dry and tasteless as to be utterly useless as food. A test of their size is that they are taken in the meshes of the mackerel nets.

Like the mackerel the pilchard is not a true migrant, but comes in from the deep sea, shoaling by day and scattering by night, and remains on for its season. Unlike the mackerel it never takes a bait,* and is but very rarely seen

* Whilst this Paper was in the press, and as a result from the reading of it, I received information to the following effect.

The fact above noted of the occurrence of the pilchard in large shoals south and west of the Scilly Islands in the early spring accounts for the appearance of the fish in the English Channel in July and August in each year. The course of their journey from the deep seas into the Bristol Channel, and thence westward round the Land's End in November, remained for explanation. Mr. William Eddy, a skilled fisherman in the matter of pilchards, tells me that for several years during which he was manager of some copper mines near Baltimore, in Ireland, he noticed lying around the islands in Baltimore Bay large shoals of pilchards for some days in every month of September or October, which would be about six weeks before the date of their usual occurrence in the Bristol Channel. The shoals hung about for a day or two, and then went off into the deep sea.

Corresponding to this statement is another which has come to me

in our seas except in its season ; but again, like the mackerel, it is too thorough a nomad to stand the confinement of an aquarium. And those of you who wish to see either of them alive must seek for them in their native haunts.

DISCUSSION.

Professor BROWN GOODE said he had heard some complaint that there were too many scientific men on the platform in these conferences, and too few practical men, but every one would agree that Mr. Cornish had shown that he had a thorough practical acquaintance with the subject, whilst he had used a thoroughly scientific method in his deductions. He had listened with great pleasure to the Paper, having been for some years paying special attention to the mackerel fishery in the United States. That fishery was one of the most important in the American waters. The produce in the year 1880 was about 132,000,000 pounds. It employed about 470 of

from Mr. R. Pollard, of Wadebridge, a gentleman largely interested in the pilchard fishery. He has advised me that the earliest shoals of pilchards which arrive annually in the Bristol Channel come in enormous quantities from the north-west (or direction of the coast of Ireland), and after hanging about in the deep water for a day or two in "Mother Ivery's Bay" (east of Trevose Head, see page 131) break up and go to the westward in small shoals, and pass St. Ives and round the Land's End into the English Channel.

Thus our two seasons for pilchards are apparently accounted for. Mr. Pollard notes the very curious fact that, after a large shoal of pilchards has broken up each small shoal formed from it keeps so much together, and to itself, that if portions of two shoals are captured in one haul they do not mingle, even though they may remain in the seine for some days. This fact, however, depends on a solitary observation. It but rarely happens that portions of two shoals are enclosed in one shot.

their finest sea-going schooners, of from 60 to 100 tons burden each, and with an aggregate capacity of about 23,000 tons, with crews of 14 to 20 men, and nets worth 450,000 dollars or more. Within the last few years, since the introduction of the purse-net to which Mr. Cornish had referred, it was not uncommon for one of those vessels to catch fish to the value of £5000 or even £7500 a year. The history of the mackerel fishery was very interesting. As long ago as the year 1600, within forty years of the settlement in New England, there were records of the colonists seining the mackerel off Cape Cod by moonlight; and it was somewhat remarkable, that on this fishery was founded the system of public schools in the United States, for within ten or twenty years of that time the first public school was founded on a tax upon the fishery. At that time, when perhaps not one hundred barrels a year were taken, they found the inhabitants petitioning to prevent the destruction of the mackerel by this method of fishing, and that appeal had been repeated at various times in the history of the fisheries, even down to the present time. In the American Court of the Exhibition could be seen a diagram showing the progress of the mackerel fishery, and the very great fluctuations which took place not only with reference to the quantity of fish caught, but the number of vessels employed. It would be noticed that in 1882 the catch was very much greater than in any previous year, so that the fears as to the destruction of the fish did not seem to be well founded. Two methods of fishing were afterwards introduced; first, the gill-net or drag-net, like that used in Cornwall, and which is still used to a limited extent at the present time. Another method introduced about the same time, and kept up for a considerable period, was what they called trailing, or dragging a bait after a vessel under sail. That

was carried on until the beginning of this century, and it was not uncommon to see a vessel with four or five poles sticking out from it, to which the bait was attached. That was given up, however, fifty years ago. At the beginning of this century another form of apparatus came into use, which was exceedingly effective for a time, and it was during the prevalence of this method that the great fisheries in the United States and the Canadian waters sprung up which had led to so many treaties from 1865 to 1870. There were from 500 to 700, or even in some years 1000 American vessels in the Gulf of St. Lawrence fishing for mackerel, and this was called the mackerel hook fishery. It was conducted in this way: the fishermen took on board a hundred or more barrels of a very oily, fat fish called the menhaden, something like the pilchard. They ground it up fine and threw it out in great quantities. The mackerel would follow this for a long distance, and come up round the vessel like a flock of chickens coming to be fed. Then the fishermen had short lines with hooks on the ends, with which they caught the mackerel and threw them over on to the deck, and with a crew of 10 to 14 men the catch would sometimes amount to 20,000 in a day. That mode of fishing was carried on for a long time, but the purse seine gradually came into use and displaced it. It was first used in 1814, but did not come into general use until 1860, and there were now probably 500 of them at work. The mackerel fishery had now been transferred from the Gulf of St. Lawrence to off the shore waters along the coast, and at the present time they followed them down to Cape Hatteras. The mackerel on the other side of the Atlantic had definite migrations, coming north in the spring of the year, when the fishermen followed them until August, when they were in the Gulf of Maine, then

they followed them back in the fall. The mackerel increased in size as they got on better feeding-ground. They disappeared for a month or so in June, when they went to the bottom and spawned. He could assure Mr. Cornish that there was not the slightest practical difficulty in working the purse seine. They were from 70 to 150 feet in depth, and 1000 to 1300 in length, and were worked by a special boat something like a whale boat, and it was quite easy for a vessel to catch as many fish as could be cured in three or four days. At first they used to give the surplus away or let them go, but now they had invented a kind of storage net, which they hung out over the side of the vessel, and kept the fish alive in it, taking out at intervals as many as they could cure before they spoiled.

Mr. KENNETH CORNISH asked if Mr. Cornish was in favour of legislation for the preservation of mackerel? Referring to what had been said in regard to the pursuit of herrings and mackerel by porpoises, he might say that he witnessed a very remarkable sight at Teignmouth in the year 1860. In walking along the sea wall they saw a great commotion in the sea, a mile out, and watching it, they soon found a shoal of salmon running in, pursued by a shoal of large grampuses, who drove the unfortunate salmon right against the wall. They seized the salmon in their jaws, threw them up, and caught them like a terrier would a rat, and when the salmon turned and went out to sea again, they pursued them. He should like to know if Mr. Cornish thought it possible to catch these cetacea, seals and other animals that preyed on salmon, herrings, and mackerel, by the use of spinning bait on a large scale? It seemed to him we were thinning down the fish, but not thinning down their natural enemies. It would not be at all difficult to make baits which would exactly represent a

salmon, mackerel, or herring, with hooks concealed internally; and they might even be impregnated with the natural flavour of the fish.

Mr. CORNISH, in reply, said, as far as his experience went, he did not think legislation was required with respect to a close time for mackerel or pilchards; they took a close time for themselves and got away where they could not be caught. Further legislation was very desirable for the purpose of regulating the fishing of our own boats in British waters; and even if what legislation there was were better enforced, it would be of great importance. With regard to catching porpoises, he should not like to tackle one weighing more than 2 cwt. in a small boat.

Mr. SHAW, M.P., in moving a vote of thanks to Mr. Cornish, said he was much interested in the mackerel fishing of the south coast of Ireland; but he had learnt a great deal he did not know before. Up to the present he always thought that if a mackerel could speak it would talk Irish, but he was now pretty well convinced that it would also speak in Cornish; and perhaps if it could speak in either language it could give a different account of its sufferings to that which had been given in the Paper. One thing, however, might mitigate one's sympathies in this respect, for mackerel had not the slightest regard for other fish which suited its taste. In the neighbourhood of Cork there was a fleet of five hundred boats engaged in the mackerel fishery. He was sorry to say there were not as many native Irish engaged in it as he could desire, because round that part of the coast the inhabitants were a poor class of men, with very little enterprise, and very few of them were men of business or capital. In another district, too, mackerel fishing had been established, and seemed likely to succeed; and he should be very much wanting in his duty if he did not refer to the great help

given there by Lady Burdett Coutts, but for whose assistance the thing could not have existed. It was very satisfactory to know that the people of the coast—a simple primitive people—had availed themselves of the assistance offered them, and there were some of the best boats engaged in the fishery now going from the Harbour of Baltimore on the south coast of Ireland. The great object of catching fish was to bring it as quickly and cheaply as possible to the table, and he did not think there was a better fishing ground in the world than that round the south coast of Cork; but hitherto facilities of transport had been rather deficient. Now, however, they were in a much better position in this respect, as there were rails now touching the fishing grounds at Kinsale, Skibbereen, Baltimore, and Bantry, and in the Bay of Bantry a steamer had been put on, so that every evening the fish caught in any of those places could be shipped, and next day it would be delivered in the cities and towns of England. The great thing to be desired was to have as few people as possible between the consumer and the fishermen, otherwise the profit was scattered about by the number of hands through which the fish passed. If there were any gentlemen present engaged in the fish business, he would recommend them to send their agents over there, who would day by day collect the fish and send it forward. He knew, from practical experience, that fishermen got very little as the result of their industry; this did not apply so much to the mackerel fishery, because it was mostly conducted by men of skill and experience who could take care of themselves.

Mr. C. E. FRYER had great pleasure in seconding the vote of thanks. The Chairman had referred to the beautiful scene presented at night when the boats were leaving the harbour, but it appeared to him the enjoyment was much enhanced when you happened to be on board one of the

vessels going to the fishing grounds. Having had the pleasure himself, he could recommend any one who visited Cornwall to endeavour to get a night's fishing on board one of those boats; for no more beautiful scene could be imagined than was presented on a fine evening on board a boat off the Land's End. The energy of the Cornish fishermen had been referred to, but, like many others engaged in the same vocation, they were remarkably conservative in their habits, and it was very difficult to induce them to adopt improved methods of fishing. He had had the great satisfaction of introducing into this country the system of preserving pilchards in oil, in the manner in which sardines were preserved in France. There could be no question that the sardine was exactly the same fish as the pilchard, and those who had not tasted them he would recommend to buy in future not the French sardines but the Cornish. He had no interest personally in giving this advice, beyond the desire of seeing an industry which he had established prospering to the extent which it deserved. As an instance of the difficulty of inducing the fishermen to take a "new departure" in fishery matters, he related that on one occasion, when off Penzance, he endeavoured to get the fishermen to put aside the smaller fish, for the purpose of preserving them as sardines, as it was found that the smaller ones were preferred for the purpose, but he had the greatest difficulty in the world to induce the fishermen to adopt that simple precaution. Every fish had to be taken out of the net, and it would have been perfectly easy for the men to put the small ones on one side and the large ones on the other, but their conservative tendencies prevailed and they would not take the trouble to do so. There was a saying that the Cornish people could make anything into a pie; and it was said that if a certain gentleman, who should be nameless, were to go there, he would be put into a pie; and just as

they were determined to put everything into a pie, so were they loth to adopt new methods of preserving fish for the market. If proper means were adopted there was no reason why enormous quantities of pilchards, preserved in salt as well as in tins, should not be sent to London and other English markets, though of course there were difficulties of transport to be overcome. Mr. Cornish had referred to the remarkable occasional disappearance of the pilchard from the coast of Cornwall, and it occurred to him that possibly the china clay works in Cornwall might have some influence on the movements of those fish. Enormous quantities of milk-white water were poured into the sea down many small streams in the county, and that might have some effect, though he did not suppose it was the chief cause of the disappearance, because the same sudden disappearance had been noticed in France. He recently came across a letter received in 1879 from a friend in France, who spoke of the sudden appearance there of the sardines in great abundance, though for more than twenty years there had been a great scarcity. The abundance which had generally prevailed since had shown large occasional fluctuations. He trusted that many other gentlemen in Cornwall would follow Mr. Cornish's example, and make a study of the movements of this and other fish with a view to the practical encouragement of those very important industries.

The resolution having been carried unanimously,

Mr. CORNISH said he did not think the china clay had much to do with the disappearance of fish, because it had been noticed that they still remained in localities where that water and also mineral water ran into the sea. They would require to watch them still more closely for some time to find out the reason for those movements.

The MARQUIS OF EXETER then proposed a vote of thanks

to the Chairman for presiding. Mr. Cornish had alluded to three kinds of mackerel, one of which, the green, was unwholesome; and he was glad to hear the explanation, because not long ago his crew, who were Irish, came one morning and said they were all very bad from eating mackerel that had been in the moonlight. He concluded that it was this green mackerel. He had oftentimes enjoyed the pleasure of fishing off the Cornish coast, and had always met with the greatest kindness from fishermen and others; and he could recommend any one who wanted a good fishing ground where they could catch all manner of fish, to go, when the wind was not to the south or west, and lie off Penzance. They might catch there every kind of fish, from the mackerel down to the beautiful jelly-fish which Mr. Cornish had alluded to, which he had often watched on a calm day struggling to make head against the tide, but eventually drifting with it; and perhaps the Chairman would recollect that they had it on the authority of a noble duke, that certain friends of his, who were as brilliant in talents as these jelly-fish were in colour, were also in the habit of drifting with the tide.

Mr. HORNBLOWER seconded the motion, which was carried unanimously.

The CHAIRMAN, in response, said it had given him much pleasure to be present at a discussion of so practical a character. There were many points on which he should have liked to touch had the time not been so far advanced, but he would only say, in correction of what Mr. Fryer had said, that the Cornish proverb was that the devil would not come into Cornwall because he was afraid of being put into a pie.

SALMON AND SALMON FISHERIES.

BY

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CONFERENCE ON TUESDAY, JULY 17, 1883.

The LORD LOVAT in the Chair.

The CHAIRMAN, in introducing Mr. Milne Home, said the work of the Exhibition would not have been complete if a paper on that most noble of our fish, the salmon, had been omitted. The importance of the salmon was very great, supporting as it does a considerable industry, supplying a vast amount of food, and affording the finest sport which in this sporting country a sportsman could enjoy.

SALMON AND SALMON FISHERIES.

IF the announcement in the Programme of this day's Conference means that there is to be an account given of the Salmon and Salmon Fisheries of the United Kingdom, I fear that any information I can furnish will not do justice to the subject; for my knowledge of Salmon and Salmon Fisheries is derived only from my experience as a proprietor of salmon fisheries in one river in the south of Scotland, viz., the Tweed; and from having had some share in managing the fisheries of the river, and of the sea-coast on each side of its mouth.

But as, according to the latest known returns, the Scotch Salmon fisheries are, in value and produce, fully one-third of those of the United Kingdom, and there are peculiarities

in the Scotch fisheries which seem deserving of attention, I venture to offer a few remarks for the consideration of the Conference.

I. Fish.

There are several kinds of salmon in the Tweed. The most common are the *Salmo salar*, or true salmon, and the *Salmo eriox*, which last kind is known also by the names of bull-trout, sea-trout, or whitling. But there are hybrids which sometimes render identification difficult.

The young of the true salmon, when first hatched, we call a "*parr*," having dusky cross bars on its sides. Hatched in December or January, these "*parr*" go slowly down the river towards their ultimate destination, the sea. But they do not venture into the sea till another skin of glistening scales has been formed over their first skin. They then receive the name of "*smolts*." If put into salt water, before getting this silver dress, they die. It is only a portion of the "*parr*" which go to sea during the first year. The rest, being probably more weakly in constitution, remain in fresh water till the following spring, when, if not devoured by natural enemies, they also put on a silvery dress, and betake themselves to the ocean.

The "*smolts*," after remaining in the sea for some months, return to their native river, having grown to about twelve inches in length, and weighing about half a pound or more. They then go by the name of "*black-tails*," having the tail and the dorsal back fin of a black colour. They hover about the lower parts of the river, not going far beyond the influence of the tide. Before winter they return to the sea; and in the following year they come back to the river as grilse in June and July. For what purpose they come then is not yet known. When they come in September and October, it is in most cases to

deposit ova and milt in the spawning beds. After they have spawned they return to the sea, and if they come back next year, my opinion is that it is in the form of a salmon—a change corresponding to that of the heifer into a cow after her first calf. This, however, is one of the points on which naturalists differ.

The young of the bull-trout are like the young of the true salmon—first parr and then smolts. When they return from the sea, they go to the higher parts of the river, and are known as "*orange-fins*," being distinguishable by a yellow colour on the belly.*

It would appear that many of the grilse and salmon, though sufficiently advanced in life, remain sterile. In the months of December and January, which is the usual time for spawning, quantities of adult salmon are seen by cod, haddock, and herring fishermen, twelve and fifteen miles from the coast, near the surface of the water, playing about, as the fishermen term it, probably being then in pursuit of food. Even in the river, during the above

* There is, however, a little uncertainty regarding the relative positions of "*Orange-fin*" and "*Black-tail.*" Some young fish, believed to be Orange-fins, having been put into a pond at Carham, and kept there for two or three years, were examined by Mr. Stirling, of Edinburgh University, and he reported on them as follows.

A fish, weighing about 2 lbs., having been examined, Mr. Stirling suggested the following account of its life history :—

"It was put into the pond in May, 1874, as an Orange-fin.

"It became a Black-tail in May 1875.

"It became a Bull-trout in November, 1876.

"It spawned about this time.

"Its progeny were hatched in February 1877.

"Its progeny became Parr in May 1877.

"Its progeny became Orange-fins in April 1878."

Mr. Stirling was therefore of opinion that the fish known as an "Orange-fin" in the Tweed, is the "Black-tail" of that river in a younger stage.

months, adult salmon have been seen, not seeking the spawning beds, but lying in deep pools.

In the Tweed, there have been numerous well-authenticated cases of salmon having been caught exceeding 70 lbs. in weight (see 'Tweed Salmon Reports,' published by Blackwood, Edinburgh, in 1867, p. 121).

With regard to the food of the salmon, I have never heard of anything having been found in their stomachs, except what they must have got when in the sea. Small haddocks, cod, and herrings have been found, as well as lugworms, sand-eels and remains of jelly-fish. The sea-fishermen believe that when in salt water they feed largely on "Mather;" or "Herring Sile," minute crustaceans, which are often in such quantities as to colour the water, and which generally betoken to the fishermen the proximity of herrings. Even when salmon are taken in parts of the river, at a distance of above twenty miles from the sea, as at my own residence on Tweedside, they have been found with small herrings in their stomach, as the only appearance of food. When they come into the river to spawn, my belief is that they get no food, except what they bring with them, and that they are then supported entirely by the oil which is in their flesh. This inference is corroborated by the experiments of the late Sir Robert Christison, who analysed the flesh of a clean salmon caught when entering the River Tay from the sea, and also another salmon when descending the Tay to the sea, after having been in the river for about six months. The amount of fatty matter was in the latter only about one-sixteenth of what existed in the former.*

* See Appendix A (page 183) for the details of Sir Robert Christison's analysis; and also for some corroborative remarks by the late Frank Buckland.

The young of the salmon, on their way down to the sea, are preyed on by many enemies. Sea-gulls and herons devour them in large quantities. When they reach the mouth of the river, there are millions of "podlies" (*Merlangus carbonarius*) watching for them. The Tweed Commissioners, to lessen the slaughter, employ boats and nets to catch these "podlies." The last return of which I have a note represents 6040 caught in May and June. Many of these creatures, when examined, were found with the remains of eight or ten smolts in their stomachs.

The migration of Tweed salmon has been to some extent investigated by the Commissioners. With the view of ascertaining the changes of size and shape in future stages of life, we for many years were in the practice of catching fish of all kinds, and putting a silver wire into the dorsal fin, with a special number stamped on it. When any of these wired fish were caught, the wire was sent to our Superintendent, with a description of the fish, by length and weight, and of the place where caught. In this way we had reported to us cases of Tweed salmon caught in the Firth of Forth, on the coast of Aberdeen, and in the rivers Don and Dee of that county. Along the coast of England to the south of the Tweed, we had cases reported to us from Holy Island, from the Tyne, from Shields, and even from Yarmouth. This last case, on account of the distance travelled, is especially interesting, the wire having been fastened to a bull-trout caught in the Whitadder, a tributary of the Tweed, on the 29th of March, 1852, and the fish having been caught in a net at Winterton, near Yarmouth, on the 2nd of April; it had travelled, therefore, nearly 300 miles in four days. Another fish, marked in the Whitadder on 10th March, 1880, was caught at Yarmouth on 5th May, 1880 (see Appendix B, page 184).

When salmon are swimming in the river Tweed up stream, it has been estimated by experienced anglers that they travel at the rate of about two miles per hour.

Salmon, in descending the river after spawning, are generally emaciated and exhausted. Many, apparently hardly able to swim, float down the stream to the sea. Every spring, large numbers are found dead at the sides of the river, or in pools.

What causes the migration of salmon is matter of conjecture. I have observed, when walking along the Berwickshire coast, salmon leaping frequently at or near the mouths of small rivers or streams; and it has occurred to me that, as they must get into rivers for spawning, instinct induces them to seek those rivers the waters of which they find most suitable for the purpose.

Certain it is that salmon, after having frequented particular rivers from time immemorial, have abandoned them, and the inference is that they betake themselves to other rivers which they deem preferable.

As an example of this, I may refer to the river Whitadder, which has a course of about forty miles from the Lammermuir Hills. This river joins the Tweed, at a distance from its mouth of about three miles; so that all the salmon caught in the higher parts of the Tweed must have passed the mouth of the Whitadder. The tide flows into it, as well as into the Tweed, flowing up the latter, for six or seven miles. Formerly the true *Salmo salar* frequented the Whitadder; but during the last thirty years no salmon of that variety has been seen in it. It is frequented only by bull-trout.

Reference may also be made to the Thames and to the Coquet (Northumberland), both of which rivers used to be frequented by the true salmon. I might also quote the

Esk in Mid-Lothian, where, about fifty years ago, I have seen hundreds of true salmon wriggling up over the mill-weirs; but there have been no such fish in that river for the last twenty years.

Where have all the salmon and their progeny gone to, which frequented these rivers? The natural conclusion is, that rivers elsewhere have been resorted to.

In some of the cases I have mentioned, and in multitudes of others, the probable cause of desertion, was the pollution of the streams by the establishment of paper-mills, dye-works, mining operations, and other manufactures, the refuse of which rendered the waters in these rivers unsuitable for salmon life.

Thus, about thirty years ago, shortly after the establishment of paper and woollen works in the upper parts of the river Whitadder, I used to see its lower parts covered with an oily scum and foam most destructive to fish.

These remarks lead me to refer to other circumstances inimical to salmon when in our rivers.

One is the formation of mill-dams or weirs, of such heights that, except in "spates" or heavy floods, the fish cannot reach any spawning grounds. In the cases of the Thames and of the Coquet, the English Fishery Inspectors, after careful investigation, gave it as their opinion that what originally caused desertion of salmon from both rivers, was the erection of impassable mill-dams and locks, which cut off access to spawning grounds. On the other hand, there are rivers where salmon have become more plentiful, as in the Tyne; and the Chairman of the Fishery Conservators of that river informed me, that he attribute this increase chiefly to the removal of mill-dams and the formation of fish-passes. It seems a well-established fact that unless the fish find suitable ground for spawning

they retain the ova and milt, causing great risk of fatal inflammation; and accordingly every winter, multitudes of fish, both male and female, are found dead and unspawned — in many cases with milt-sacs and ovaries diseased.*

I believe that the state into which our rivers get by excessive drought, is another cause of much unhealthiness to salmon. The rain falling on our agricultural districts rushes off at once through land drains; so that our rivers, instead of continuing in flood for a week or ten days, fall to their ordinary level in three or four days; and in dry weather, the fish congregate in pools, where the quantity of water is so small, that the supply of oxygen for respiration is insufficient.

A curious fact may be referred to, which perplexed the late Frank Buckland, viz., the entry of grilse into our rivers, at a season when it is probable they do not come for spawning. In the north of Scotland, they enter the rivers on the east coast, in January and February, but on

* Return by Mr. List, Superintendent of Tweed Water Bailiffs, of salmon, grilse, and bull-trout, found dead or dying in the rivers which were taken out of the river and buried, distinguishing the spawned and the unspawned.

	Season 1880.	Season 1881.	Season 1882.	Season 1883.
Spawned	4694	2542	11438	3996
Unspawned . . .	528	365	3189	864

The late Frank Buckland, in his 19th Report, p. 34, says:—"A question of considerable importance, bearing on the salmon disease, has arisen, viz., whether a female salmon has the power to withhold her eggs? Now, I know most positively that she has the power."

the west coast, though on the same latitude, not till May or June. The explanation suggested by Mr. Archibald Young, Fishery Inspector for Scotland, seems to me correct, founded on the relative temperatures of the sea and of those rivers. The sea on the west coast is from two to three degrees warmer than on the east coast. On the other hand, the rivers flowing eastward into the German Ocean, lose their winter temperature, before reaching the sea, more rapidly than the rivers flowing by a shorter course towards the west; because the snow-clad mountains, from which both sets of rivers flow, are nearer the west coast than the east coast, and therefore the west-flowing rivers are, at their mouths, colder than the east-flowing rivers at their mouths. The fish may therefore seek to get out of the cold sea-water on the east coast, by at once entering the rivers flowing there into that sea; whereas on the west coast, the fish may incline to remain in the warmer sea-water there, until the temperature of the rivers has risen, after the snow has melted.

This solution of the problem, being one of a meteorological character, is now being tested by thermometers, which His Grace the Duke of Sutherland has kindly caused to be placed and observed in the Sutherlandshire rivers.

A question occurs on Tweedside, regarding the spawned and spent fish, called "*kelts,*" which are often so emaciated, that the clause in our Act of Parliament forbidding the capture of "*foul, unclean, and unseasonable*" fish, has been held to apply to them. Sometimes, however, these kelts become, before reaching the sea, so improved in condition, that they are considered wholesome as food, and, being improved in appearance, are, when taken in

the nets, not restored to the river. The expediency of destroying the kelts has also been maintained, on the ground that they devour "*parr*" in large quantities. I incline to think this a mistake. The kelts generally go down to the sea in February and March, at which time the "*parr*," like the common "*minnows*," hide themselves in the muddy bottom or sides of the river, or under stones. A neighbour of mine, who kept a supply of minnows in a pond in his garden for many years, told me that they always, during the winter months, buried themselves in the mud. My gamekeeper, when in winter he wants "*minnows*" for trout fishing, tells me that he has to seek for them among tree roots and other rubbish along the banks, by means of a small net. This is also probably the case with "*parr*."

II. Fisheries.

Having offered these remarks in regard to *Fish*, I proceed to the second part of the programme, viz. *Fisheries*, which I presume refers to the persons who fish for salmon, and to the rules for controlling their modes of fishing.

In Scotland, as I believe is the case also in England and Ireland, the original right of fishing for salmon is in the Crown, the privilege being capable of being exercised only by those who can show a Crown charter.

Until about thirty years ago, the Crown rights in this matter seem, in Scotland at least, to have been little attended to.

About that time, steps were taken by the Department of Woods and Forests, to ascertain what proprietors who were fishing for salmon, could show Crown charters.

The investigation began in the south-east of Scotland,

and I was called on among others. I was able to show a good prescriptive title for both river and sea fishings, but many of my neighbours were not so successful, and then, of course, the Crown officers, their right to the fishings having first been established or acknowledged, advertised the salmon fishings to be let to those who offered the highest rent—a preference, however, being given to riparian proprietors.

This investigation has been carried on along the east coast of Scotland, and I believe also the west coast.

At my suggestion a return was obtained from the Woods and Forests two years ago, of the amount of these Crown salmon fishings for the years ending respectively Martinmas, 1871, and Martinmas, 1881, from which it appears that the sum drawn for Crown leases of salmon fishings in Scotland in the former year was £3198 1*s.* 2*d.*, and in the last-mentioned year £5110 14*s.*; this progressive increase arising from the additional fisheries taken possession of by the Crown officers.

The total amount of the rental received by all kinds of leases of salmon fisheries in Scotland, is believed to be about £250,000.

There are, however, no statistical returns which can be relied on for accuracy on this point. The old Scotch Fishery Board (which was abolished last year by the Scotch Fishery Act) concerned itself only with sea fish. Since the new board was organised, there has been, as authorised by that Act, an inspector of Scotch salmon fisheries appointed by the Secretary of State for the Home Department, who is entitled to seek information regarding the numbers and value of salmon caught, but who has only recently entered on his duties.

The regulations in Scotland for salmon fishings are, many of them, the same as in England.

(1) Thus there is an annual winter close time; which in Ireland continues for 168 days, in England for 154 days, in Scotland for 170 days. In the open season of summer, there is a weekly close time; lasting in Ireland 48 hours, in England 42 hours, in Scotland 36 hours.

(2) No fixed nets are allowed in our rivers or in our estuaries near the river mouths; and no nets with meshes smaller than one and three-quarter inches, so as to avoid catching parr, smolts, or small river trouts.

(3) Pollution of rivers, to such an extent as to kill salmon in them, is *nominally* prohibited; but the clauses in all the Scotch Acts are so weakly worded, that I don't know of any case in Scotland, except one, where fishery proprietors or Fishery Boards have been able to enforce these prohibitions for the protection of fish.

No power was by these Acts even attempted to be given to *prevent* pollution. It is only after a fish has been killed by it, that action is allowed; and even then it is exceedingly difficult, indeed, almost impossible, to show, that when a fish is found dead, it died from the effects of poison which came from any particular mill.

The Tweed Fishery Act has existed for 26 years, but it was only last year that a case occurred, where the Commissioners ventured to exercise their powers in this respect. Noxious matters were discharged from a mill, which killed every kind of fish in the river for two or three miles below the mill. There was a general outcry at such an outrage. A leading Edinburgh angling club endeavoured to prosecute, but was baffled by a technical defect in the wording of the Scotch Freshwater Fisheries Act. The Tweed Salmon Commissioners, however, called on the county Pro-

curator Fiscal (who is the local Public Prosecutor in Scotland) to institute proceedings in respect of the destruction of thousands of Salmonidæ, which gave to the Tweed Commissioners a right of action. The County Sheriff awarded a sum of £2, being the full allowable penalty. The party convicted appealed to the Supreme Court in Edinburgh. There, the Sheriff's judgment was affirmed, with an award of £12 of expenses; but it cost the Tweed Commissioners £157 to obtain the conviction!—a proof of the utter insufficiency of the existing law to meet even a case so manifestly flagrant as that just referred to.

This subject of river pollution suggests a remark of wider application. Important as it is to afford to Fishery Boards more legal power for the protection of fish, the gross pollution of our rivers, streams, and lakes by sewage and manufacturing refuse, ought to be prevented for the sake also of higher interests. The health and domestic comforts of thousands of our population demand, that there be a stringent law declaring such pollution to be a crime, irrespective of any proof of injury to fish or to individual riparian proprietors. A public officer ought to be appointed, not only to prosecute such offences when they occur, but to prevent the discharge of noxious matters (whether from towns or private houses), and even the erection on the banks of rivers of any manufacturing works, which would cause gross pollution of the water.

(4) Another point of importance, as regards Scotch salmon fisheries, is the mode of enforcing the prescribed rules of fishing.

On the Tweed we have no difficulty with the lessees of the fishings, or the men employed in working the nets, who are about 476 in number. But we have great difficulty in repressing the poaching which goes on during the

long nights of the annual close time (extending for nets from September 14th to February 15th), especially in the upper reaches of the river, where spawning beds are situated. In these districts, there is a dense manufacturing population, in and near the towns of Hawick, Jedburgh, Galashiels, Selkirk, Innerleithen, and Peebles; and the mill-workers greatly enjoy the recreation of going out in parties at night, with torches, to capture, by means of rake hooks and hand nets, salmon in the shallow streams.

On an average of the last two years, the number of poachers detected and convicted at the instance of the Tweed Commissioners was 221 in the year; the cost of prosecuting them was £266, and the amount of fines and expenses awarded to the Commissioners was about £149.

The number of our Water Bailiffs or River Watchers has been, on an average of the last two years, 49 during the six months of close time, and 13 during the rest of the year.

In order to pay the wages of bailiffs, the cost of prosecutions, and the salaries of managing officials, the Tweed Commissioners are entitled, under their Act of 1857, to assess themselves, and the other proprietors of fishings, to the extent of 20 per cent. on the rentals or values of the fishings. These amount at present to about £13,000 yearly, so that by assessment we have about £2,500 at our command for protection and management.

If, however, the terrible fish epidemic, which for the last two or three years has affected the Tweed, continues, we must expect our income from fishing rents to fall, not only because of the decrease in the number of fish, but because of the disinclination of sportsmen to frequent our river for angling, the enjoyment of which is undoubtedly lessened by the ghastly sight of diseased fish.

As the salmon disease has already been a subject for separate discussion at these Conference meetings, I abstain from any remarks on it, beyond mentioning that during the last three years, our bailiffs have drawn out of the Tweed and its tributaries, altogether 27,100 salmon, grilse, and bull-trout, either dead or dying, in order to bury them. The value of these, at an average weight of 7 lbs. each, and an average price of 1*s.* per pound, amounts to about £20,000 sterling.

(5) The Commissioners who manage the Tweed fisheries, are all persons whose income from fishings exceeds £30 yearly, or who possess a river frontage of half a mile. They form a numerous body, and hold a meeting once a year, when they appoint a Committee of Management, consisting of twelve of their own number, resident on or near the river, and known to take an interest in fishery matters. His Grace the Duke of Roxburghe is Chairman of the Committee.

In other parts of Scotland, the management of the salmon fisheries is, or rather ought to be, in District Fishery Boards, which were appointed to be constituted by two Acts passed in the years 1862 and 1868. But the proprietors of salmon fishings so much disliked the constitution of these Boards, that when the sheriffs of counties summoned them to meet, to elect Boards for the different districts, very few proprietors responded to the call. Scotland had been, by three Government Commissioners, previously divided into 105 districts, each comprising one or more salmon rivers; but the result was that no more than 30 Boards were formed, and during the succeeding ten years, eight of these Boards ceased to meet, so that *there are now altogether not more than 22 Boards in existence.*

To show the present state of things, I may quote the

following from a report of the Scotch Fisheries Improvement Association, read and adopted at the public annual Meeting held at Edinburgh in May 1881:—

"There are seven counties in Scotland, with 32 rivers, *which have ceased to be frequented by salmon;* owing, first, to dams built across the rivers, which prevent the fish getting up to spawn; and, second, to manifold pollutions from town sewage, bleach-fields, chemical works, and other manufactories.

"In eight counties with salmon rivers in them, *there are no District Fishery Boards.*

"In one of these counties, viz., Ross and Cromarty, there are no less than 32 salmon rivers, *all without official protection.*

"In Argyleshire, where there are about 30 salmon rivers, there is but one District Fishery Board, and its place of meeting (when it does meet) is in the Island of Mull."

There has thus been almost an entire collapse of the arrangements which were devised by Government, and sanctioned by the Legislature in 1868, for the protection and management of the Scotch salmon fisheries.

In the year 1870, this fact became known to Government, through the reports officially made by the different county sheriffs, who had been appointed by the Act of Parliament to take steps for forming the District Boards. I must do the Government of that day the justice to say, that viewing the matter in a serious light, they lost no time in endeavouring to obtain the best information with a view to a remedy. The Honourable Mr. Bruce (now Lord Aberdare) then Secretary of State for the Home Department, appointed two competent Commissioners, the late Frank Buckland and Mr. Archibald Young of Edinburgh, to visit the different counties in Scotland, and report, "*how far District Fishery Boards are in operation in Scotland,*

and whether any alteration in their *constitution* is desirable." The Commissioners at once proceeded with the inquiry, and made a report stating that, to procure the necessary information, they had visited the principal salmon rivers in Scotland (forty-six in number), and had personal meetings with twenty-two District Boards, and also with many landed proprietors interested in the fisheries. They further reported, that whilst the total number of fishery districts which had been designated by the Act of Parliament to be managed, each by a separate board, was 105, yet "at this moment (viz., in 1871) *there are not above* 30 *District Boards constituted and working*."

The Commissioners also reported that the *constitution of the boards* was unsatisfactory, and they suggested some modifications, though apparently without much confidence in their likelihood of success.

Shortly afterwards, there was a change of Government, which may, perhaps, have been one reason why no steps were then taken to remedy a state of things so injurious to a great national industry which supplies a large amount of much prized food, and gives employment to about from 14,000 to 15,000 of the population in Scotland.

What has been the consequence of matters having been allowed to remain in the nearly total absence of any proper authorities for enforcing the law? Over two-thirds of the country, both in our rivers and along our sea-coasts, poaching in annual and weekly close times,—capturing of salmon fry,—river pollution,—obstructions in rivers, and illegal netting, have been prevailing, without check or hindrance.

If asked for evidence of this, I refer to the testimony of Mr. Young, who knows more about our salmon fishings than any one else, and who in the year 1877 published a pamphlet, in which he states as follows: "*Poaching*

is universal along the coast of Argyle, and among the islands; the central point being the town of Oban, where thousands of sea trout are annually caught by persons who have not a shadow of right to fish for them, and which are openly sold without any interference." *

Then, turning to the east coast of Scotland, I refer to the testimony of Mr. A. B. Hogarth, Aberdeen, who at a public meeting of fishery proprietors, held last April in Edinburgh, voluntarily came forward to support a resolution affirming that salmon in Scotland were decreasing in number, and stated, "that the amount of *over-netting* which had taken place on the sea-coasts during the last ten years, was *something past all comprehension.* He added, that he had been a fisherman for thirty-five or thirty-six years; but it was only within the past ten years, that things had gone on to such an extent." This testimony is all the more reliable, being given by a tenant of extensive coast fisheries, who had been carrying on, without objection or interruption, a practice admitted to be alike injurious and illegal.

These local testimonies from Scotland are confirmed by the returns from Billingsgate market, where an accurate record has long been kept and published of the numbers of salmon received there from England, Ireland, Scotland, and other countries. Taking the returns of the last ten years, and comparing the average number of salmon brought there, during the last five years, with the average number brought during the first five years, I find there has been during the last five years an *increase* from England of 20 per cent., and from Ireland an *increase* of 2½ per cent., but from Scotland a *decrease* of 20 per cent.

* 'British Industries,' p. 287 (Stanford, Charing Cross, 1877).

There being a general conviction in Scotland of the decline of our salmon fisheries, and no appearance of any intention on the part of the Executive Government to adopt remedial measures, a number of fishery proprietors and representatives of angling clubs, conceived the idea of forming an Association for endeavouring to make the Scotch public aware of the virtual non-existence of any proper system of protection and management of the fisheries, and also to urge upon Government the necessity of better legislative arrangements.

At a public meeting in Edinburgh, held in January 1881, the Scotch Fisheries Improvement Association was established with that view. His Grace the Duke of Sutherland consented to be President; and the Earl of Breadalbane, the Earl of Dalhousie, Lord Polwarth, the late Sir Robert Christison, Sir James M. Gibson, and myself were appointed Vice-Presidents; with a Council of fifteen members, practically acquainted with the subject of salmon fisheries.

This Association has accordingly, by means of public meetings for discussion, by circulation of Reports, and by sending memorials and deputations to Government, endeavoured to make known and urge the necessity of remedial measures.

I also individually endeavoured to contribute some amount of help towards the same object, by the publication of a small tract, to explain the reason why the District Fishery Boards authorised by the Acts of 1862 and 1868 were so much disapproved of in Scotland.*

I there ventured to suggest that the lines of the

* In Appendix C., p. 188, extracts from this tract are given by the courteous permission of the Executive Committee of this Exhibition.

English system of River Conservators (as they are termed) might be followed in Scotland. The English Boards consist of two classes of members, proprietors and lessees of fisheries. The *proprietors* are selected by Quarter Sessions, the number on the board for each district being previously fixed by the Secretary of State for the Home Department; and to these selected members, there are added a certain number of *ex officio* proprietors, having a rental from fisheries exceeding £30. The other class of persons on the English Boards, are *lessees* of fishings, and consist of persons holding licences to fish; for in England (and in Ireland also) it is the law, that persons wishing the privilege of fishing, whether by net, rod, or boat, must take out licences, and pay for them certain dues to be approved of by the Home Secretary. These licence dues form a fund, which is at the disposal of the River Conservators.

It will be observed from this explanation, that only a small number of the members on the English Boards are members *ex officio*. The majority are selected, on account of their qualifications for the duty, by others who are supposed capable of judging of these qualifications.

Now what is the constitution of the Scotch Boards, as explained in the Salmon Act of 1862?

All the Boards consist of the same number of members, whatever be the size of the district; viz., three fishery proprietors from the lower parts of a river, and three from the upper parts. If there be in either of these districts, only two fishery proprietors, then, whatever be the number of proprietors in the other district, the total number on the Board must be four. And if in one of the parts of the river there is only one fishery proprietor, then the total number can only be two members

besides the Chairman. With regard to a Chairman, he is not elected by the members of the Board, as is usually the case. The Act appoints the proprietor of largest fishery rental in the district to be Chairman, *without reference to his having any other qualification;* and he has both a deliberative and a casting vote.

The result of such an arrangement was to throw the whole power of the Board into the hands of the lower proprietors, inasmuch as the Chairman, on account of his high rental qualification, is almost always connected with the lower part of the river.

The consequence is, that the upper proprietors, seeing that they have no influence in directing the action of the Board, decline in most districts to become members, or at all events to attend the Board meetings.

Another objection to the Boards is the expense to which members would be subjected, by having to assess themselves and other fishery proprietors, to defray the costs of prosecutions, to pay the wages of water-bailiffs, and to pay the salaries of officials,—the Act declaring that all these expenses fall on the Boards; and in many districts, the fishery rents are not sufficient to meet these expenses.

It was likewise felt to be an invidious and odious duty to throw on proprietors the institution of prosecutions for the imposition of fines and imprisonment.

Another serious difficulty which militates against the practicability of these Boards, is the scanty number of resident proprietors in many of the northern and midland counties of Scotland, and the great distance of their dwellings from one another, rendering attendance at meetings almost impossible.

These being some of the objections to the proposed

Boards, and which, as already mentioned, prevented the formation of no more than about 20, out of the 105 required, the practical question now is, what can be thought of, as likely to succeed in place of these Boards?

The chief suggestion made in the Report of the Commissioners appointed by Lord Aberdare was, that where in any district a Board has not been constituted, a Fishery Inspector, nominated by the Secretary of State for the Home Department, should exercise all the powers of a Board.

I failed to see how this plan would work. The arrangement which I suggested, and which I may now briefly sketch, was as follows:—

1st. To allow no persons to fish for salmon in Scotland, without taking out a Licence—the amount of the dues to be fixed by the Secretary of State for the Home Department.

2nd. To have in districts embracing one or more salmon rivers, a Board, consisting, as in England, partly of proprietors and partly of lessees of salmon fishings; the proprietors who are to be members of the Board, to be selected by a committee, consisting in each county, of the Lord Lieutenant, the Convenor of the County, and the Sheriff;—the lessees of fishings who are to be members of the Board, to be selected at a meeting of persons holding Licences, called publicly by the Sheriff; and the Chairman to be elected by the Board—either from among their own number or otherwise—the election being yearly.

3rd. With regard to expenses, these are of three classes: 1st, salaries of officials to assist in the management; 2nd, wages of water bailiffs; and 3rd, cost of prosecutions.

The first two classes of expenses would be defrayed

out of the funds to be raised by licence dues;—a plan which I have reason to believe would meet with the support of the Tweed Commissioners.

The last class of expenses should, I think, fall on the officials who in Scotland are now and have always been entrusted with the administration of the criminal law. Looking to the severity of the punishment for offences authorised by the Salmon Acts, consisting of fines reaching up to £20, and of various terms of imprisonment up to six months, it seems to me unconstitutional, inexpedient, and anomalous, to give to Boards the power, and still more to impose on them the duty, of acting as prosecutors. In cases of an analogous nature, such as night poaching, killing game in close time, fishing for oysters, lobsters, and mussels in close time, the prosecutions are, and can only be, at the instance of the Procurator Fiscal,—an official who is subject to control, and even to dismissal, for any impropriety or mismanagement. The expenses of such prosecutions are audited by the county magistrates, and, if found correct, paid out of the county funds. Why should the same rule not be followed in regard to offences under the Salmon Acts?

What is the practice in England in regard to the prosecution of offenders under the Fishery Acts, I do not know.

In Ireland, offences against the fishery laws are taken notice of by the county constabulary, and prosecutions are conducted by them, as well as by Fishery Conservators.

I have now related, I fear at too great a length, what we have been doing or trying to do in Scotland to bring about some amendment in our salmon fishery laws. During last year, a Fishery Act was passed for Scotland, abolishing the old, and creating a new fishery board, which has been so far a step in the right direction, that

it includes among the powers of the Board a right to take cognizance of salmon, for the purpose of collecting information of a statistical nature.

The Act, however, gives no power to the new Board to make any change in the law bearing on the constitution of the Fishery Boards. But in the reports which the Board is to make annually to the Home Secretary, suggestions may be offered for the regulation and improvement of the fisheries—*i.e.*, sea as well as salmon fisheries; and it is to be earnestly hoped, that this power will be promptly exercised.

What Scotland wishes and requires for salmon protection, is to be put on the same footing as England, where, —as Mr. Spencer Walpole says in his Report of 1879 on the English salmon fisheries, "*Every river in England capable of producing salmon, is now under the protection of a Board of Conservators.*"

Many of my countrymen think, and I confess I share the opinion, that we in Scotland are too far off to be heard by the Executive Government. Therefore I am glad of the opportunity of opening my lips on this subject at the present influential Conference, trusting that what has now been spoken by me, however feebly, may reach the ears of those who have power to provide a remedy.

In conclusion, may I express a hope that this Exhibition will strengthen the appeal which we Scotchmen have been making, for the better protection of our freshwater fish, by the evidence it affords of what other nations are doing in that respect, especially Canada and the United States. Let us not be ashamed to confess past indifference on the subject, but take a lesson from others, to enable us to fulfil a duty laid on us alike by the gifts of Providence, and by a regard to the interests of the country.

DISCUSSION.

Professor BROWN GOODE (United States Commissioner) said he had listened with very great interest to the Paper which Mr. Milne Home had presented, and he rose to say a few words, which were perhaps invited by the closing sentences of the address, concerning what America had been doing in the way of salmon culture. He was led to do that by the fact that certain documents had been distributed from Canada, which had rather a tendency to depreciate what had been done in fish culture, not only in Europe, but in the United States. It had been said that fish culture was only an experiment, and had not been attended with commercial success: he, however, wished to say that it was in no sense an experiment, but that in the United States and in Canada it had been a decided success, and was so recognised by every one. It was not likely that the American Congress, or the Canadian Government, would for a period of ten or twelve years keep on making annual appropriations for fish culture if they were not satisfied that it was not only a success from a scientific stand-point, but a success from a commercial point of view. In the United States the general Government had appropriated considerably more than a million dollars, and the individual States a sum almost as great. Up to 1798 large numbers of salmon were caught in the Connecticut river, but until 1870 the fish disappeared entirely from the river, and until about 1875 no salmon whatever were seen in the river. In 1875, however, the salmon began to appear, and this was the direct result of the planting of a large number of eggs in that river three or four years previously. Then again in the case of Sacramento River

of California, where about two million young fish were planted yearly, the catch had increased in five years from five million pounds to fifteen million pounds, and in 1881 there were more fish than could be utilised by all the canning establishments on the river. He would not proceed with the multiplication of examples, but would refer to the fact that the fish in the Detroit River, where the United States and Canada had established hatcheries, had been increased, and the supply immensely improved. The shad was taken in twenty or thirty great rivers on the Atlantic coast, and was for several months of the year a most important food supply. About twenty years ago it was found that the supply of shad was beginning to decrease, and Fish Commissioners were organised with the special object of increasing the supply. He had seen shad which four or five years before were selling at 4*s.* or 5*s.* a pair, and were therefore beyond the reach of poor people, become so cheap and common that they could be bought for a shilling a pair, which was entirely the result of fish culture. Professor Baird had been the leading spirit of fish culture in America. He was asked recently if Professor Baird was not an enthusiast, and he replied that he was not, but a man possessing the widest general and philosophical knowledge of natural laws, whose sound judgment and experience had enabled him to take up the work of fish culture and carry it on on an immense scale in the United States. People were sometimes dissatisfied because fish were sometimes planted in streams and nothing was heard of them afterwards; but it was the theory of their Commission and of their Government that it was a proper thing to make experiments, and if they happened to be unsuccessful there was so much ground eliminated over which it was un-

necessary to go again. He thought the experiments which had been successful ought to be allowed to balance those which had not. Experiments in fish culture in Europe, especially in Holland and Germany, had yielded exceedingly promising results. Mr. Whitcher had singled out two rivers in Canada, out of many, for the purpose of supporting his view that fish culture had not been a success, and had stated that although a large quantity of salmon was taken out of certain waters in 1871 there was none in 1881. Mr. Whitcher, as Commissioner of Canada, was charged with the preparation of a report to the Canadian Government upon the state of the fisheries. The report for 1882, which surely ought to have been within Mr. Whitcher's access when he published the circular, stated that the salmon fisheries nearly all over Canada, had been much better in 1882 than within the preceding ten years; and other testimony showed that there had been a magnificent improvement. He knew that Mr. Wilmot, who had been criticised somewhat in the circular, would feel some diffidence in speaking on the point, but he thought he owed it to him to point out that the official documents proved that fish culture had not been in any sense a failure, but a decided success.

Mr. WILMOT (Canadian Commissioner) said it was with considerable diffidence that he rose to make any remarks upon that important question. He had been much delighted by the very instructive paper on salmon fisheries, a subject which of course required a great deal of time to enter into fully. Mr. Milne Home, on the opening of the Exhibition, visited the Canadian Court, and he felt sure, from the way in which he expressed his views, that he was extremely delighted with the *modus operandi* of fish culture in Canada. A few days ago Mr. Home called upon

him, and stated that he was somewhat astonished to see from a circular he had received from one of the officials in Canada that fish culture had been seriously found fault with, at the same time stating that as he was about to read a paper on salmon fisheries, it would be his duty to refer to the subject, as it was of great importance, and affected very seriously the interest of the salmon fisheries throughout the world. He was pleased that Mr. Home had not done so, as it gave him the opportunity of going into the matter very fully; but as it appeared that many other persons had received circulars of the same kind, he felt, on behalf of that great and important portion of the British Empire, Canada, whose government had thought proper to expend large sums of money in advancing the interests of salmon culture, he ought to say a few words on the point. Salmon culture was initiated in Canada by himself as a private individual, and he was pleased to say that from the day it was initiated it had gone on progressing and prospering. The Government of Canada at first thought very little of it, but looked upon it as one of those things which required further development before they could grant aid. In 1868 there was a small grant of £40, but the annual grants now amounted to some $30,000 a year, which showed what importance the Government now attached to salmon culture. The salmon fisheries of the world required the utmost protection, and care must be taken to prevent fish being destroyed during the breeding seasons. Salmon culture ought to be carried out in every country where those fish were indigenous to the waters. In Canada fish culture had been carried on for a length of time, and its fruits were beyond cavil. There were, however, some people who found fault with everything, no matter what it might be,

and he regretted very much that Mr. Whitcher, a colleague of his in the Canadian Fisheries, should have thought proper to issue circulars amongst the Commissioners, stating that fish culture had not been satisfactory. Mr. Whitcher's own documents, evidently not written nor read by himself, however, proved the very reverse of that statement, and the blue-books of Canada contained returns which showed most conclusively the beneficial results arising from the protection of rivers and the raising of salmon by artificial means. After quoting a number of returns from Inspectors of Fisheries and other officers from the annual reports of 1882, proving that there had been a very remarkable improvement in the salmon fisheries of Canada, he said it would be quite unnecessary to read the individual reports of fishery officers in all parts of Canada, which, with only a few exceptions, indicated that the salmon were increasing wonderfully during 1882. He might also mention that he had received letters stating that the catch of salmon by netters and anglers in 1883 had been in excess of any previous period, especially in those rivers where salmon hatcheries were in operation. It was the duty of all civilised governments and intelligent people to adopt such means as would bring about a better supply of food, and he had no hesitation whatever in saying that the means adopted in Canada had in most instances been very beneficial. Perhaps on some future occasion the matter might come on again; if so he could give volumes of even stronger evidence in proof of the success attending fish culture.

It was painful indeed to be obliged at this Conference to refer to the circular issued by this well-known official crank in Canada, who, to gratify personal spleen, had wantonly attacked an industry of world-wide beneficial

reputation; more especially as the Canadian Minister at the head of the Fisheries Department, and himself, were here on behalf of that country advocating the importance of fish-cultural operations in the Dominion, the practical display of which, at this great International Fisheries Exhibition, had gained for itself great popular favour, and also materially aided in the general exhibit, and placed Canada amongst the foremost of the nations for efficiency and completeness in the science of artificially propagating fish. From the gratifying way in which Professor Goode's remarks and his own had been received on this subject, it was clearly unnecessary to refer further to this "under the belt" stab in the circular, feeling assured that similar conduct is always frowned down by the manly English public.

Mr. C. E. FRYER (Home Office) said if the Exhibition fulfilled no other object than that of making people think, it would have achieved a great work. They had just received a great deal of information about the manner in which fish culture was carried on in the United States and in Canada, and as to the beneficial results derived from the artificial culture of salmon, and he would just say a few words to show the benefits which had resulted from the protection of salmon in this country even without artificial hatching. In 1863 the value of the salmon rivers in England and Wales was about £18,000; at the present time the value of the same rivers was somewhere about £150,000. That increase, large as it was, by no means represented the possibilities of English rivers, if they were purified and greater facilities given for the access of salmon into the upper waters to spawn. This had already been done to a certain extent; and, in addition, restrictions had been placed on the power of man to catch the salmon in

the mouths of the rivers, and to destroy them when they were on the spawning beds: and to those two things alone was due the large increase which had taken place. He did not for a moment wish to depreciate the value of the efforts made by fish culturists in Canada and the United States, but he thought before they went very largely into salmon hatching in England they must do a great deal more to make the rivers fitter to receive the fish to be put into them, by removing pollutions. Means should also be adopted to enable the salmon to pass at their own free will up and beyond the dams which cut them off from the spawning beds. Mr. Milne Home had referred to the question of pollutions, and he would take that opportunity of congratulating him upon the result of an action which had been tried at the Court of Session, the result of which would be that one of the tributaries of the Tweed would be freed from its pollutions. The artificial culture of fish had been of enormous advantage in stocking waters with fish, which those waters had never contained before; but he thought that by purifying the rivers, by placing ladders which would enable the fish to surmount the weirs, by protecting the fry of the fish in the upper waters, and in the lower waters by preventing the fishermen entirely blocking the mouths of the rivers by enormous nets, they would be able to greatly improve the salmon fisheries; and then artificial culture might come in. If they took the pollutions out of the Thames, and put ladders up the weirs, they might bring back the day when twenty or thirty salmon used to be caught at a haul, and when salmon used to sport themselves opposite the home of the Legislature at St. Stephen's. He hoped the Legislature would take heart of grace, and insist upon the pollutions being removed from the Thames and other

rivers, and then they might see, not only salmon, but fish of other kinds greatly increased.

Mr. JAS. H. CROSSMAN, in proposing a vote of thanks to Mr. Milne Home for his very valuable Paper, said that one of the beneficial results of the Conferences was that gentlemen of experience from all parts of the world were brought together to discuss these interesting questions. He had always been of opinion that if the regulations governing the Tweed fisheries could be applied to the other rivers of Scotland they would not have to complain of the falling off in the Scotch salmon fisheries. As a member of the Executive, he might plead as some excuse to Mr. Milne Home for the audience not being larger, that there had just been another important lecture on "Fish as Food," by Sir Henry Thompson; but the able paper which had been brought before them would be printed and distributed, and would therefore not be lost sight of, but be thoroughly well considered.

Mr. BLOOMFIELD seconded the vote of thanks, and said that he, as an Irishman, had felt some pleasure in finding that Scotchmen were not always able to do things as well as an Irishman. As an old magistrate of thirty years' standing he knew something of the matter, and he could say that they were in a much better position in Ireland than they appeared to be in Scotland, from what Mr. Milne Home had stated. The representatives of Canada and the United States had, he thought, given them some hints which were worthy of consideration. They had shown what the younger Governments were doing to further the interests of the people by increasing the supply of fish; and he was afraid the old country was very much behind them. Fish was an important article of food for the

people, and as such should be protected and looked to by the Government. He would ask the Home Office to reconsider the matter, and not only because they had not taken the pollutions out of different rivers, but because they have failed in their duty by neglecting to propagate the fish in the rivers that were to receive them. He hoped that what had been said would not pass out of their minds, but would remain there until they had induced the Government to do their duty in the matter.

Mr. MILNE HOME, in reply, said that if there had been nothing more than the opportunity which had been given to his friends from the United States and from Canada to give the explanations to which the meeting had been listening, the Conference had done good. He had been somewhat astonished when he read the circular referred to, because it was in contradiction to what he had read of the complete success of artificial fish culture, and he could not believe it possible that such statements were correct, but he felt it was not for him to bring the matter forward in a paper relating only to the fisheries of this country. They had had the pleasure of hearing from Mr. Wilmot and Professor Brown Goode that the statements were not to be credited, and he cordially agreed with the views which had been expressed as to the value of artificial hatching. They had in their own country a hatchery belonging to his friend Mr. James Maitland, which he had visited twice, and knew to be a success. There was one in Dumfriesshire, and there were two or three others, on a smaller scale. He hoped they would soon have more of those private establishments, but he also could not help thinking and saying that there ought to be some encouragement given to them by Government. If they were to appoint an inspector to visit those esta-

blishments and report upon them, with a view to make known what they were doing, it would be a good thing. He had for some years past endeavoured to possess himself of the Reports of the Canadian and United States Commissioners, and had obtained from them very valuable information; and he thought we in this country ought to learn a lesson from Canada and the United States.

Mr. MILNE HOME then proposed a vote of thanks to the Chairman, which was carried unanimously.

The CHAIRMAN, in response, thought the pith of what had been said was, that they should all use their best endeavours to induce Government to assist in the propagation of fish and in the increase of the number of salmon in this country. Out of evil often came some little good, and he thought the circulation of the documents which had been referred to, instead of doing harm, had brought out more clearly the great success which had attended the artificial propagation of fish.

APPENDIX A (*see page* 152).

SIR ROBERT CHRISTISON'S conclusions were founded on the examination of a salmon entering the River Tay from the sea weighing 20 lbs., and of a kelt weighing 27 lbs., taken in a tributary of that river from a pool, where spawned fish were known to congregate, on their way back to the sea.

Sir Robert says that "the clean salmon presented abundance of fat under the skin, and in masses between the muscles." The kelt, "a male fish, was lank in the belly, and soft in the flesh." "I subjected it to analysis in the same way as the clean fish. I cut one piece of muscle from the dorsal region a little in front of the dorsal fin, and another from the ventral region directly opposite; so that the one should represent the *thick* and the other the *thin* of a slice of salmon."

"Four hundred grains of each were cut into fine chips," and then subjected to a chemical treatment, which he describes. The following elements were obtained:—

—		Dorsal.	Abdominal.	Mean.
Salmon	Oil	16·66	20·40	18·53
	Fibrine, albumen, &c. . . .	20·57	18·82	19·70
	Saline matters and water . .	62·77	60·78	61·77
		100·00	100·00	100 00
Kelt .	Oil	1·20	1·30	1·25
	Fibrine, albumen, &c. . . .	16·92	17·22	17·07
	Saline matters and water . .	81·88	81·48	81·68
		100·00	100·00	100·00

On these results Sir Robert remarks, that "the nitrogenous solids of the clean salmon, and its fat or oil, constituted together in round numbers 38 per cent. of its flesh;—that there is decidedly more fat in the *thin* or dorsal region;—that there is very little difference in constitution between the dorsal and

abdominal regions of a kelt;—that the kelt is a much more watery fish than a clean salmon; and that this is slightly owing to a deficiency in nitrogenous ingredients, but much more to an enormous deficiency of oil or fat, which is reduced to almost a sixteenth of the amount in a clean run fish." (*Proceedings of Royal Society of Edinburgh for Session* 1871–72, *page* 695.)

I find that the opinion expressed by me regarding the food of salmon when in rivers, was entertained by the late Frank Buckland. In his 19th Report, p. 18, he says that in the salmon, "there are no less than fifty pyloric appendages. Upon these I found firmly adherent a dense mass of white fat. In my report for 1868, I promulgated the idea that one of the principal uses of the pyloric appendages was not only to secrete a fluid which assists in digestion, but also to act as *a depository of fat.* This fat is derived from the food which the salmon eats when in salt water. It is stored up in a layer underneath the skin, as well as upon the pyloric appendages. *During the stay of the fish in fresh water, this fat is gradually absorbed,* and its principal use is to go towards the formation of the milt and ova. In a fish running up from the sea, therefore, we find that the milt and ova are very small, while the fat on the pylorus is often so abundant as to almost obscure them from view." Again, at page 20 of the same report, Buckland says, "I do not think salmon eat much in fresh water. They subsist principally, as I have shown at page 18, on a store-house of fat which is laid up in their pyloric appendages. Nevertheless they take worms. In the Trent and in the Rhine the worm is a favourite bait, especially at flood-time. The food of the salmon, therefore, consists of herrings, sprats, smelts, sand-eels, fry of fish, and lugworms."

APPENDIX B (*see page* 153).

WITH reference to the cases of Tweed salmon caught in 1852 near Yarmouth, it may be noticed that the late Frank Buckland, in his Fishery Report for 1876, mentions the surprise with which he had learnt, "that every year large numbers of bull trout are

caught in the neighbourhood of Yarmouth," there being no rivers in that part of England frequented by *Salmonidæ*. He says, "the fishermen begin to take these trout in the middle of April, and go on catching them to the latter part of July. The fishermen catch them near the shore from 30 to 130 yards from the beach. These trout exist in more or less abundance along the whole coast of Norfolk. They are migrating southwards. Their object, without doubt, is food, especially sand-eels and the fry of sea-fish, which are in abundance on the sands of the coast of Norfolk. These bull-trout must come from rivers flowing into the German Ocean to the north of Yarmouth." He then enumerates these rivers, including the Tweed, and adds that he had "come to the conclusion that the bull-trout caught on the Norfolk coast, are bred in one or other of these rivers." (Report, p. 16.)

That salmon migrate enormous distances is established by a fact communicated to the Tweed Commissioners by Dr. Günther of the British Museum, that he knew "of an instance of a French sea-trout (now in the British Museum) being caught in the Bristol Channel." ('Salmonoids of the Tweed,' Blackwood, Edinburgh, 1867, p. 100.)

In reference to two questions in my lecture, viz., the migration of salmon, and the deterioration of salmon in condition, whilst remaining long in fresh water, I here add some tables and notes taken from the Tweed Salmon Reports published by Blackwood, and also from some more recent reports by the River Superintendent, not published, but communicated to the Tweed Commissioners from time to time.

These extracts also give definite information regarding the position in the scale of fish-life, of the "*orange-fins*," "*parr*," and "*black-tails*."

Extracts from Reports made to the River Tweed Commissioners by their Experimental Committee.

1. Young fish, considered to be orange-fins, about 100 in number, were put into a pond at Carham, belonging to the late Richard Hodgson Huntley, Esq., in May, 1874, and were detained in it for five years, fed with bullock's liver.

These fish were from time to time examined by the Committee,

and in their presence were weighed and measured by Mr. List, Superintendent of Water Bailiffs.

In February, 1877, a number of small fry made their appearance in the pond, which were assumed to have been hatched there, from the ova of the detained fish.

Mr. J. B. Stirling, of the Edinburgh University, the assistant of Mr. Turner, Professor of Anatomy, and who had studied freshwater fish scientifically, having, on the invitation of the Committee, visited Carham and examined the fish, drew out the following Report:—

" Assuming that the fish, or some of them, put into the pond in May, 1874, were orange-fins, they became black-tails in May, 1875; they became bull-trout in November, 1876, and some of them would spawn about this time.

" The progeny would be hatched about February, 1877, and would become parr in May, 1877, and orange-fins in April, 1878."

2. The result of the measurements of 80 fish in Carham Pond, between 4th July and 13th December, 1876, showed an average increase in length of three-quarters of an inch. The measurements of 78 fish between 13th December, 1876, and 17th May, 1877, showed an average increase in length of only one-tenth of an inch.

3. Into a deserted stone quarry, near Coldstream, filled with rain-water, two smolts, about 3 inches long, were put by boys, out of mere amusement. One of these grew into a salmon, which, when five years old, weighing 1½ lbs., was caught and sent to Mr. Stoddart, of Kelso, who had it boiled for dinner. He reported that it was not unpalatable. The other smolt grew into a bull-trout, and lived for seven years. It died during a very severe winter, when, on account of the water being frozen, it could not be fed.

4. The Duke of Buccleuch's gamekeeper at Bowhill was for some years in the practice of putting a few smolts into a freshwater pond, and feeding them regularly with bullock's liver. He reported that the smolts which grew into salmon throve for about three years, and then died, but that bull-trout smolts kept in good condition for a longer period.

5. Fish marked by wires in the River Tweed, and elsewhere.

Kind of Fish.	Marked.	Weight.	Length.	Recaptured.	Kind of Fish.	Weight.	Length.
			inches.			lbs. oz.	inches
Two Salmon smolts	April or May 1851	..	..	17 Aug. 1852	Grilses .	3½ 0	..
					,,	4 0	
Orange-fin or Trout-smolt	April or May 1851	..	..	11 May 1854	Clean Bull-trout	5 0	..
Smolt . .	Spring, 1854	1 oz.	..	July 1855	Grilse .	3½ 0	..
Bull-trout smolt	15 May 1857	..	..	25 May 1858	Bull-trout	3 0	..
Salmon smolt	15 May 1857	..	..	9 Aug. 1857	Grilse .	3½ 0	..
Grilse, near river mouth	31 Mar. 1858	2 lbs.	..	2 Aug. 1858 at Carham	Salmon .	8 0	..
Black-tail .	Oct. 1859	8 to 12 oz.	..	15 Mar. 1861	Whitling.	1½ to 2 lbs.	..
Whitling .	29 Sept. 1870	1¾lbs.	17	26 July 1872	Whitling.	2½ 0	18¾
Salmon . .	29 Sept. 1870	21½ ,,	37	12 Nov. 1871	Salmon .	25 0	?
Bull-trout .	29 Sept. 1870	2¼ ,,	18	15 Aug. 1871	Bull-trout	5½ 0	?
Black-tail .	12 Oct. 1870	12 ozs.	12	1 June 1871	Whitling.	0 17	13
Grilse . .	10 Nov. 1870	4½lbs.	23	22 Feb. 1871	Grilse .	4 0	?
Black-tail .	12 Oct. 1871	21 ozs.	14½	19 Aug. 1872	Whitling.	2½ 0	18
Orange-fin .	17 Apr. 1873	1¾ ,,	6½	1 June 1874	,,	1 8	17½
Black-tail .	25 Sept. 1873	9 ,,	12½	12 June 1874	,,	1 3	15¼
Grilse . .	25 Oct. 1873	4½lbs.	24	1 Apr. 1874	,,	3 9½	24
,, kelt .	11 Mar. 1875	5 ,,	26½	16 Mar. 1875	Grilse-kelt	4½ 0	?
Black-tail .	10 Nov. 1875	12 ,,	13	17 Aug. 1876	,,	0 16	16½
,, ,, .	10 Nov. 1875	10½ozs.	12	31 Mar. 1876	Black-tail	8½ 0	13
,, ,, .	10 Nov. 1875	11 ozs.	13	2 Aug. 1877	Bull-trout	3 12	21¼
,, ,, .	11 Oct. 1877	10½ ,,	11	26 Mar. 1878	,, ,,	0 5	10½
,, ,, .	7 Nov. ,,	11½ ,,	13	20 Apr. 1878	Black-tail	0 10	13½
,, ,, .	,, ,,	13 ,,	13	12 May 1879	Bull-trout	4½ 0	22
,, ,, .	,, ,,	11 ,,	12	18 Aug. ,,	,, ,,	2¾ 0	19½
,, ,, .	,, ,,	14½ ,,	14	27 Aug. ,,	,, ,,	0 28	16½

Kind of Fish.	Marked.	Weight.	Length.	Recaptured.	Where.	Kind of Fish.	Weight.	Length.
		lbs. oz.	in.				lbs. oz.	in.
Bull-trout kelt	29 Mar. 1852	3 0	..	2 April 1852	Yarmouth .	Bull-trout	3½ 0	..
,, ,,	29 Mar. 1852	3 0	..	2 April 1852	Shields . .	,, ,,	4½ 0	..
,, ,,	29 Mar. 1852	10 0	..	Aug. 1852	Eyemouth .	Label and part of salmon found in stomach of cod.		
Three Black-tails.	Autumn 1858	..	..	July 1861	Aberdeen; one in Don, and two in sea.	Three Whitlings	2 lbs. to 3 lbs.	..
Black-tail	Oct. 1859	8oz. to 12 oz.	..	Aug. 1861	North Esk .	Whitling .	1½ lb. to 2 lbs.	..
Black-tail	20 Sep. 1870	1 0	13	25 Sep. 1871	North Esk .	Bull-trout	2 1	18
,, ,,	13 Oct. 1870	0 12	12	5 June ,,	Lamberton .	Bull-trout	2 10	20
Bull-trout	13 Oct. 1870	3½ 0	20	30 Nov. ,,	Coquet . .	,, ,,	4 13	24
Black-tail	12 Oct. 1871	1 0	12	13 Aug. 1872	Stirling . .	,, ,,	1 7	15
,, ,,	19 Sep. 1872	0 18	15	18 July, 1873	River Dee .	,, ,,	0 36	18
,, ,,	10 Oct. 1872	0 12	12	1 Nov. 1872	Whitadder .	Black-tail	0 12	12
S. smolt .	17 Apr. 1873	0 1½	5½	14 May 1873	River Mouth.	Smolt .	0 1½	5½
Black-tail	10 Nov. 1875	0 13	13	4 July, 1876	Stirling . .	Bull-trout	0 28	17
,, ,,	18 Oct. 1876	0 13½	13	2 Aug. 1877	Firth of Forth	Bull-trout	1 12½	16
,, ,,	11 Oct. 1877	0 8	11	3 July, 1878	,, ,,	Sea-trout	1 0	16
,, ,,	7 Nov. 1877	0 9	11½	23 July, ,,	,, ,,	,, ,,	2 4	..

APPENDIX C (*see page* 167).

In the November number of the *Fortnightly Review* (for 1881) there is an instructive article on the Salmon Fisheries of Great Britain by Mr. Fred. Eden. The views he expresses will have a useful effect in awakening public interest to a subject of much national importance. Mr. Eden, having acted for several years in all parts of the United Kingdom as Government Inspector and Commissioner, in regard to Salmon Fisheries, has had great opportunity of knowing the condition of those fisheries, and of judging what is necessary for their prosperity.

Mr. Eden is evidently apprehensive that, unless some strong measures are taken, the stock of salmon will soon disappear from our rivers. To prevent this, he says it is absolutely necessary to lessen the catch of salmon. With that view he recommends the entire stoppage of net fishing in rivers, except where the tide reaches; and even in tidal waters, he is for prohibiting night fishing. Another suggestion he makes, is the formation of a central office, so that, instead of "separate establishments and different officials for each of the three kingdoms," there should be more uniformity of management, by what he calls a "consolidation of the Fishery Offices," viz. by the creation, as I suppose, of an office in London.

Mr. Eden regrets that he is unable to supply statistics, or any official evidence, to justify his convictions as to the unprosperous condition of our fisheries; no small proof, by the way, of the lamentable absence of information regarding an important national industry, which every well-constituted Government ought to possess.

Some amount of statistical information, however, may be obtained from the official record kept at Billingsgate Market, of the number of boxes of salmon which arrive there from different parts of the United Kingdom. True, London is not the only large town to which British salmon are sent for sale; but it receives an

immensely larger supply than any other town; so that if its market records distinguish the different divisions of the United Kingdom from which the supplies come, any considerable increase or decrease of these, through a series of years, will indicate a change in the productiveness of our rivers.

The number of boxes from Scotland for the years 1877, 1878, 1879, and 1880, were respectively 28,189, 26,465, 13,929, and 17,408. The average of these four years is 21,497. But in looking back to the previous six years' returns, it is found that the average of these six years was 26,038 boxes. In one of these six years, the number of boxes exceeded 31,000.

This diminution in these ten years is the more remarkable, because during that time the numbers of nets and of improvements in the modes of fishing have been constantly increasing.

It is a further indication of the unprosperous condition of the Scotch Salmon Fisheries, that, about a year ago, an association for the improvement of these fisheries was formed, with the Duke of Sutherland at its head, and with a council of influential proprietors, all more or less interested in the preservation of the Scotch Salmon Fisheries. This association, with a membership already of 159 persons, and supported by 69 local angling clubs, could scarcely have obtained such immediate and, influential support, had there not been a strong and general conviction on the part of the Scotch public, that our salmon fisheries are in a very unprosperous state.

One of the first acts of this association was to send out a circular to the chief constables of counties, asking, "*Whether there are any rivers in your county, which were formerly frequented by salmon, but in which they are not now to be found; and if there be such, what are the causes which, in your opinion, now prevent salmon entering them?*"

The answers to this circular showed, "*that in seven counties salmon appear to have forsaken rivers formerly frequented by them.*" The names of these seven counties are enumerated in the lately printed and published report of the association.

These answers further state, as probable causes of this desertion of rivers by salmon, *pollutions*, *obstructions*, *and poaching.*

Another query put to the chief constables was to ascertain if "*proper arrangements exist for the proper observance of the provisions of the Salmon Fishery Acts of* 1862 *and* 1868, *for the protection of salmon in the salmon rivers of your county?*"

From the answers to this query, it appeared that *in eight counties* (the names of which are given), each containing several fishery districts, *no Fishery Boards exist.* In one of these counties, there are no less than thirty-two salmon rivers; and in another county (but not one of these eight), viz. Argyll, where there are also thirty-two salmon rivers, there is only one Fishery Board, viz. in the Island of Mull. It appears that, in terms of the Salmon Act of 1862, the whole of Scotland was perambulated by Government Commissioners, with the view of officially determining the districts in which Fishery Boards were to be formed. The districts fixed on by these Commissioners numbered 105, each of course containing one or more salmon rivers. The Sheriffs of Counties, by appointment of Government, summoned the fishery proprietors in these districts to meet, with the view of forming Boards; but in most districts the call was not responded to; and at present there are no more than about twenty Fishery Boards altogether, independently of the Tweed Commissioners.

It is true that the absence of Fishery Boards in some districts is there partially compensated for by such protection as can be afforded by individual proprietors, through whose property, or part of it, salmon rivers run. This is the case in Sutherlandshire, and in some parts of Inverness-shire, Ross-shire, Perthshire, Elgin, Argyllshire, and Caithness. Their protection of salmon is of course less efficacious than that of Statutory Boards. But supposing their protection were as good, the fact remains, that there are at least two-thirds of the Scotch salmon rivers without any protection against pollutions, obstructions, and poaching.

Therefore, the first point of inquiry surely should be, why has the scheme of protection introduced by the Government Salmon Acts of 1862 and 1868 so completely failed; and why should no less than twelve years have been allowed to elapse, without any remedy being applied, or even proposed?

It appears that, in or shortly before the year 1870, this fact of

failure had become known to Government; for special Commissioners were in that year appointed to inquire into the matter, and report on "the effect of recent legislation on the Salmon Fisheries in Scotland." Lord Aberdare, who was then Home Secretary, directed the attention of the Commissioners to various points, and among them the following:—

> "*As to local fishery management; how far are District Boards in operation, and whether any alteration in their constitution is desirable?*"

The two Commissioners appointed to make this inquiry were the late Dr. Frank Buckland, and Mr. Archibald Young, the present Fishery Inspector for Scotland.

They state in their official Report, that, to enable them to obtain the requisite information, they sent to District Boards and to proprietors, as well as to tacksmen of salmon fisheries, circulars containing thirty-six queries, to most of which answers were received.

The Commissioners say that they afterwards personally inspected the principal salmon rivers in Scotland, forty-six in number, and had personal meetings with twenty-two District Boards, and with a number of landed proprietors interested in the fisheries.

On the point above referred to, the Report bears, that whilst the number of Fishery Districts designated by the Commissioners under the Acts of 1862 and 1868 was 105, "at this moment there are not above 30 District Boards constituted and working!"

The Commissioners in their Report suggest, as a cause for this failure of the scheme of Fishery Boards, "the smallness of many of the districts, and the poverty of the fishings;" explaining this by adding, that "such comparatively trifling streams as the Alness, Armadale, Aylort (and ten others named), and many others, have each been formed into a separate district."

The Commissioners do not point out how "the smallness" of a district, and the "poverty of the fishings" in that district, prevented the formation of a Board. But it is presumed, what they mean is, that when the rent or value of the fishings in any particular river is so small, that no reasonable rate of assessment would be sufficient to pay the expense of a Board (with a clerk to record proceedings and levy assessments, as also to pay watchers and

conduct prosecutions), the formation of a Board was felt to be impracticable.

With the view of meeting this difficulty, the Commissioners suggested, that "if the system of District Boards is to be carried out and extended, we are of opinion that many of the smaller adjacent districts might be advantageously combined."

It will be observed that the Commissioners, in offering this suggestion as a remedy, speak of it in no terms of confidence. Undoubtedly some expense would be saved by having one clerk for a district embracing three or four Boards. But, on the other hand, the greater distances which members of such a Board would have to travel, might prevent attendance at meetings; and the rivers in the enlarged or combined district might still yield so small a rental, that any reasonable assessment on that rental would not provide watchers for all the rivers.

The Commissioners, apparently from want of faith in the efficacy of Fishery Boards, even when combined, referred to another plan, by stating that "it has likewise been proposed, that *inspectors should be appointed, as in England, who should exercise the powers of District Boards in those districts where Boards do not exist*, and who should have a seat at meetings of District Boards, but no vote."

And this suggestion the Commissioners, at the conclusion of their Report, actually adopt as a recommendation to Government, in the following terms, viz. "*that Government Inspectors should be appointed, to enforce the provisions of the Salmon Fishery Acts in districts where Boards have not been constituted.*"

But this recommendation seems one of doubtful practicability. In the first place, though it is said that in England, Fishery Inspectors exercise the powers of District Boards, the evidence of this statement is not referred to. In the second place, when it is said that the Government Inspectors are to "exercise the powers of Boards," and "enforce the provisions of the Salmon Acts," how can these powers be exercised by an official residing in Edinburgh? Is he, in the absence of any Fishery Board in a district, to appoint watchers for the rivers there?—or order prosecutions?—or levy assessments?

The Commissioners having consulted such District Boards as were in existence when they drew up their Report, it may be useful to see what answers these Boards gave, bearing on local management.

In reference to the query, "*Is the constitution of District Boards satisfactory*, as regulated by 25 and 26 Vict., cap. 37 (1862), and 31 and 32 Vict., cap. 128 (1868)? *If not, state what improvements you would suggest, and why?*"

From the *Forth* District an answer came containing the following statement:—"It should be made obligatory on proprietors of salmon fishings to appoint and maintain efficient District Boards, unless it be intended to depute their powers to Government Inspectors. At present there are no District Boards in the great majority of the salmon fishery districts. But even if there were, for all the rivers, I think it absolutely necessary that there should be qualified inspectors, with power to examine and inquire into all fisheries, and cause the enactments relating to them to be carried out." "The absence of authoritative inspection is a direct encouragement to neglect of the regulations."

From the *Tay* District an answer came containing the following statements:—"I am opposed to the manner in which District Boards are constituted. No Board with four to three can be a fair tribunal. Boards should be constituted of an equal number of upper and lower heritors, their chairman having a deliberative but not a casting vote. Instead of Boards, I would rather give the management of the fisheries to two paid Commissioners, provided they had ample powers."

"District Boards should not have direct authority, but should report to a Central Board in Edinburgh. Some means should be devised for preventing individual interests being prejudicial to the general good of the fisheries in the district."

"Six members are sometimes more than can be found in the district of a small river. Again, six members are fewer than will admit of all the interests of a larger district being fully represented."

From the *South Esk* District an answer came containing the following statements:—"I consider District Boards of little use,

except to give information to a Government Commissioner who knows his work, and has power to enforce the law."

Another proprietor wrote: "I do not approve of Boards. There ought to be Government Inspectors, independent of the proprietors. The inspectors should make an examination of the river at least twice a year—the proprietors and tenants, using the weirs and exercising the right of fishing, being subject to his orders, with a right of appeal to the Sheriff."

Another proprietor wrote as follows:—"The Board, of which I am a member, is utterly useless; the proof of which is, that there is here a good salmon river without salmon, at least above Brechin. The members cannot be got together. We don't understand all matters connected with salmon fishing, and we don't like to interfere with our neighbours. None of the upper proprietors think of attending the Board meetings, because there is no salmon fishing above Brechin; so the lower proprietors are allowed to do as they like."

From the *Ness* District the following remarks came:—"The constitution of the Boards is not satisfactory. The districts also are badly arranged. The Boards are formed on the principle of having all matters relating to the fisheries conducted by fishery proprietors, and giving a completely preponderating interest to the upper as against the lower proprietors, or the reverse, without any representation of the public interest. The Boards should be composed in whole, or at least to the extent of two or three members, for each district, of Government Commissioners; and the existing arrangements for giving a dominating influence to one class should be abolished. The district should also be enlarged. I think the Ness, Beauly, Conon, and Nairn, and their tributaries, should form one district, and a specified number of members should be entitled to call meetings, or require the clerk to do so."

Another proprietor in the Ness District wrote as follows:—"All fishery proprietors should have a voice at the Board, or else be exempted from taxation.

"I suggest also that a district embracing several rivers, such as the Ness, might advantageously be placed under the management

of some intelligent person, who should have power to make alterations in the bed of the river, so as to increase its productive power as a spawning bed, or to improve its capabilities for angling by stoning it, &c. At present, proprietors are chary of doing anything at their own expense, because other people may benefit by it as much as they, without incurring expense."

Another proprietor in the Ness District wrote:—"The Board does not work satisfactorily, the whole power being vested in the upper proprietors, since they succeeded in depriving me of the chairmanship, by reducing my rent from the highest in the district to its present low rate. Under present circumstances, upper and lower proprietors can scarcely agree."

From *Nairn* Fishery District the following remarks came:—"A Board has been constituted, but is not in a working state." "The Nairn will never be a fishing river. It is valuable only for breeding."

From *Lochy* Fishery District the following remarks came:—"Undue weight and importance is given to the proprietor who has the largest rental, as regards his right to sit as chairman, with a deliberative as well as a casting vote. The consequence is, that he assumes and acts as an autocrat."

From *Creran* District the following came:—"There is no Board here. The formation of a Board should be compulsory; or proprietors who assess themselves for the protection of the fishings should be entitled to exercise all powers for the protection of the fish, without the interference of those proprietors who consider their fishings valueless. At present, those who wish to protect the salmon are prevented by others, who have little interest in the fish."

From *Awe* District the following answer came:—"This Board may illustrate the working of Boards as constituted under the Acts. There are two upper and two lower proprietors on the Board, the chairman being a lower proprietor, and having a casting vote. One of the upper proprietors has not been represented at the Board, but should be. The lower proprietors could have carried any measure against the upper, who have therefore practically no power to compel the Board to carry the Act into

execution. Hitherto the upper proprietors protected the fishings, while the lower proprietors have got the fish. It is in the interest of the upper proprietors that additional measures are required."

From *Shiel* District the following answer came:—"There is no Board;—but some authority should exist. Probably, if districts were larger, the formation of a Board would be easier; but I believe inspectors would be better than a Board, every member of which is more or less influenced by his own interests, while inspectors would be influenced only by the public good."

From *Findhorn* District the following answer came:—"Our Board seldom meets, and the control is much in the hands of the chairman, who occupies that position as having the largest (netting) interest. Of course the tendency is to work against the interests of upper proprietors, if they are conflicting with those of the lower proprietors. The Board must be one-sided, the chairman having the casting vote. But they are too much one-sided, and unnecessarily so."

From *Clyde* and *Leven* District the following answer came:—"A Board was constituted, but it was never set working. Proceedings were taken in Court by Sir James Colquhoun, and he got the Board quashed."

From *Doon* District the statement came that the Board, "being found to be unworkable, was allowed to lapse."

From *Conon* District the answer was, that "a Board was constituted, but it became extinct."

The following suggestion came from the *Lochy* District Board, viz.—"There should be a staff of marine watchers, provided with a steam launch, to put down the depredations upon salmon committed by trawlers within the southern limits of the district of the River Add, and the point of Ardnamurchan.

"This provision is necessary, owing to the prevalence of the capture of salmon in the Sounds of Jura and Scarba, Loch Linnhe, the Sound of Mull, and the numerous arms of the sea opening therefrom. These watchers should be under the control of a general Board."

On a review of the information and suggestions contained in the foregoing memoranda, it will be seen—

1st. That the plan of entrusting to Fishery Boards the carrying out of the provisions of the Scotch Salmon Acts of 1862 and 1868 has almost entirely failed.

Some of the principal rivers in Scotland, viz. the Tweed, Forth, Tay, North Esk, South Esk, Dee, Don, Deveron, Ythan, Findhorn, Spey, Ness, and Lochy, are under the management of Fishery Boards or individual proprietors; but apparently all the rest of the Scotch salmon rivers are under no protection whatever.

2nd. That in the Fishery Boards which exist, there is evidence of want of harmonious action, on account of the diversity of interests of the members; one half of the members consisting of upper proprietors, who seldom see salmon, except in close-time, when they cannot legally be caught; and the other half consisting of lower proprietors, who possess all the fishings of any value.

3rd. That almost all the Fishery Boards, apparently conscious of their inability duly to carry out the provisions of the Salmon Acts, suggest the appointment of Government Inspectors, not only to visit the districts and assist Boards with their advice, but even to exercise powers for enforcing observance of the law.

Some of the answers sent by the Boards to the Commissioners' circular, bear on the constitution of the Boards, and are deserving consideration, in reference to the question whether any attempt should be made to continue the existing system of Boards. By the provisions of the Salmon Acts, the Boards must consist of two sets of proprietors—called in these Acts the upper and the lower proprietors. The greatest number of each set is required to be three; and if there be less than three in either the upper or the lower part of the river, the number of members on the Board must then be four, viz. two of each set. Curiously enough, the Boards are not allowed to elect a chairman; nor is a chairman selected for them by any one who might judge of his qualifications. The Act appoints as chairman the proprietor who has the largest fishery rental or value in the district, ignoring altogether any other test of suitability.

Now, it is important to observe that the interests and duties of these two sets of proprietors are not only different, but adverse to each other. Each set, of course, wishes to capture as many salmon as they can. For this purpose the lower proprietors wish to detain the fish in the lower parts of the river by allowing or tolerating obstructions, natural or artificial, which prevent the fish ascending to the higher reaches. On the other hand, the upper proprietors desire the removal of such obstructions; and especially as the expense of removing them would fall chiefly on the lower proprietors, on account of their larger rentals. Many examples of contention on this account, between the two sets of proprietors, are afforded by the answers from several of the Districts.

In these conflicts the lower proprietors generally can outnumber the upper proprietors; as even though one of the former should be absent from a meeting, the chairman naturally sides with them, and he has a casting as well as a deliberating vote.

In the answers from the Boards, it is frankly admitted that, each set of proprietors generally fight on behalf of their own individual interests, and that the interests of the public are overlooked. Whilst it is the object of each set of proprietors to catch as many fish as they can, it is the interest of the public, that the numbers caught should not be so great as to exterminate the stock, on the well-recognised principle, that profits ought to come out of yearly dividends, and not out of capital.

It is, however, only fair to the Boards to add, that many of them, as if sensible of the almost unavoidable tendency of members to attend chiefly to the interests of their own parts of the river, suggested that, instead of Boards, there should be inspectors, appointed by Government, with ample powers to devise and carry out measures of management which the Boards, constituted as they were, found themselves unable to adopt.

Perhaps it may be asked, why should there have been so complete a failure of protection by means of local Boards in Scotland, when a similar system of Boards prevails successfully in England and Ireland?

On the other hand, it is not incorrect to affirm, that even in England and Ireland the action of the River Conservators has

not always been smooth. The jealousies and sparring of upper and lower proprietors on these Boards, are occasionally referred to by the late Dr. Buckland in his Annual Reports. But in England and Ireland the local Boards have several advantages over those in Scotland, to secure harmonious action.

In the first place, there are Government Inspectors in England and Ireland, men of great intelligence, experience, and social weight, whose duty it is, and whose practice it has been, to assist Boards by their advice, and also to visit districts, when personal inspection is necessary.

In the second place, the funds at the command of the Boards in England and Ireland are not raised by assessment on the members of the Boards, as under the Scotch Acts. The funds are, in both of these countries, raised by means of licences, which have to be taken out for the use of nets, boats, and rods, and the dues for which are mostly paid by persons not members of the Boards. The amount of licence dues paid in the year 1880 for England was £9331, and for Ireland £9700. It is a proof alike of the efficiency and popularity of licences in England, that two years ago that system was extended to include angling for trout, which (at only 1*s.* per rod) in England already yields a yearly income of above £1500.

Then, besides the funds raised by licences, there is in Ireland important assistance given by the Coast-Guard for repressing poaching along the sea coast, and by the Constabulary for punishing persons guilty of polluting rivers.

In the third place, the Government Inspectors in England and Ireland draw up annual reports, to be laid before Government and Parliament, in which not only is there information respecting the state of the fisheries generally, but particular information of the operations of the local Boards in charge of the different rivers.

In the fourth place, it should be recollected that Scotland, especially in the Highland districts, is less densely peopled by resident proprietors than England and Ireland. The distances which members have to travel, to attend Board meetings is, therefore, much greater in many parts of Scotland, than in the other divisions of the kingdom.

Notwithstanding this last drawback, it is very probable that, were arrangements introduced similar to those in England and Ireland, the system of Fishery Boards in Scotland might be continued, and steps taken to extend them. Especially is it desirable to adopt some other plan of raising funds than by obliging the members of Fishery Boards to assess themselves and their neighbours. It is scarcely reasonable to expect, that proprietors of fishings, especially when their fishery rental is small, will voluntarily constitute a Board, whose proceedings would involve the members, not only in the expense of employing watchers, but in legal proceedings for removing obstructions, stopping pollutions, &c.

The aversion to such self-imposed assessments is all the more natural, when it is remembered how heavily taxed all subjects entered in the valuation rolls of Scotch counties are, for police, prisons, lunatic asylums, poor rates, schools, &c. &c.

Another valuable suggestion may be obtained, from the mode of constituting the Boards of Conservators in England. There the Boards include three classes of persons: first, owners or tenants of fisheries in the district, not below a certain yearly value or river frontage; second, persons selected by the Justices in Quarter Sessions, the number being previously determined by the Home Secretary; and, third, persons selected by those holding licences for fishing in the district, the number depending on the money value of the licences. In Scotland, under the Salmon Acts, the Fishery Boards consist entirely of proprietors, in respect merely of being connected with those parts of the river which put them into antagonism with one another. In England, whilst some of the members are on the Board in respect of being owners or occupiers of fishings above a certain standard, the majority of the members are elected and selected with no other qualification except fitness for the duty, in the opinion of those appointed by law as thought competent to judge.

The constitution of the English Fishery Boards is therefore, in principle, greatly superior to that of the Scotch Boards; and in any future legislation for Scotland, this point should be kept in view.

Above all, there should be for Scotland an appointment of

official inspectors, with the powers and duties of the inspectors in England and Ireland. For England, there are two most able and intelligent inspectors (Mr. Spencer Walpole and Professor Huxley), each with a salary of £700 yearly, a Government office in London, and a secretary, who has a salary of £160 yearly. For Ireland, there are three inspectors, equally able and intelligent, Major Hayes, Mr. Brady, and Mr. Johnston, each with a salary of £700, a Government office in Dublin, and a secretary, who has a salary. These inspectors are in frequent communication with the District Fishery Boards, not only by correspondence, but by personal visits to the rivers, and thereby afford to the Boards much valuable advice and assistance.

Why should there be no similar arrangement for Scotland? The following estimates have been given of the yearly value of the Salmon Fisheries in the three divisions of the kingdom:—

	By Mr. Caird in 1868.	By Mr. Young* in 1877.
	£.	£.
England	30,000	100,000
Ireland	320,000	400,000
Scotland	200,000	250,000

These figures are surely sufficient to establish the importance of the fisheries in each division of the kingdom.

If the preservation of salmon in our country be allowed to be an object of national importance, why should the same means for attaining that object, adopted in England and Ireland, not be applied to Scotland?

The obligation of Government to look after those fisheries, which afford alike a large supply of wholesome food to our population, and means of extensive employment to the industrial

* The figures in this table are taken from Mr. Young's Treatise on Salmon Fisheries in Stamford's series of 'British Industries.' It is understood that Mr. Young's information was derived from official returns, so far as regards England and Ireland; and, as regards Scotland, from his own personal knowledge of the Scotch rivers, and returns furnished by clerks of District Boards.

classes, has been so far acknowledged, and so far fulfilled for Scotland, that a Board many years ago was established in Edinburgh for the "encouragement and better regulation" of Herring Fisheries, by enforcing the provisions of various Acts, which fix an annual and weekly close-time, specify the size of the meshes of nets, and require registration of boats. The Act of Parliament also places at the service of that Board a gunboat, with a crew and an officer of the Navy, to assist the Board in the execution of its duties. In connection with this object, offices are provided in a Government building in Edinburgh, with a secretary, two clerks, two general superintendents, and upwards of thirty local inspectors. By establishing such a department, Government and Parliament have acknowledged the obligation to look after and regulate our Scotch Herring Fisheries. Are Salmon Fisheries not equally entitled to State protection? Of late years, Government and Parliament have been extending protection to other wild animals of very inferior importance, such as crabs, mussels, oysters, sea-fowl, and land birds, fixing a close-time for each, imposing a penalty on offenders, and authorising the Procurator-fiscal to prosecute, at the public expense. Looking to these facts, why in the case of salmon should the State throw on individuals the duty and expense of prosecuting persons who violate the provisions which the State chooses to enact? Salmon, whether in the sea or in rivers, are no more private property than herrings. They are the property of the Crown, and no riparian proprietor, either on our rivers or on the sea-coast, can fish for salmon except he can show a grant or a lease from the Crown. But the Crown does not thereby divest itself of the obligation to preserve from extermination, what it has leased or what it keeps in its own hands in trust for the nation.

On these grounds, it is hoped that Government and Parliament will feel it to be a duty to devise better means of protecting salmon in Scotland than at present exist; and for this an opportunity is afforded by the fact of there being already in Edinburgh a Board of Fishery Commissioners, occupying apartments in a Government building, where there is sufficient space for an additional office applicable to Salmon Fisheries.

As in this Paper on behalf of Scotch Salmon Fisheries, the appointment of inspectors has been urged, with powers similar to those of the inspectors in England and Ireland, it would be wrong to conclude without adverting to Mr. Eden's disapproval of having separate inspectors for each division of the United Kingdom. He says, at present "there are separate establishments and different officials for each of the three kingdoms. But one policy, and one set of men to carry it out, would tend largely to efficiency and economy." He adds, that "by consolidation or amalgamation of the Fishery offices, uniformity of management would be obtained." (Page 639.)

If Mr. Eden means that there should be only one set of inspectors for the whole kingdom, with offices in London, it seems very doubtful whether either efficiency or economy would be thereby secured. Surely inspection would be both more efficient and more economical, were the officials for Ireland to reside there, with an office in Dublin, and those for Scotland to reside there, with an office in Edinburgh, where they would be nearer to their work. "Uniformity of management," which Mr. Eden deems of importance, could quite well be secured, by the same instructions being issued by Government to each set of inspectors.

One of the greatest disadvantages to which the Scotch fisheries and Fishery Boards are exposed, is the non-existence of any inspector to visit the Fishery districts, and collect materials for framing an annual report. A still greater service would be rendered were Inspectors appointed with power to visit the districts and attend Meetings of the Board, as *ex-officio* members.

Now that the utter failure of the Fishery Board system, and the non-existence and need of an efficient inspector in Scotland has been made publicly known, a heavy responsibility will lie on Government if steps are not immediately taken to provide a remedy.

There ought to be the less hesitation on the part of Government to devise some measure for affording protection to the Scotch Salmon Fisheries, that, during the last twenty years, owing to the assiduity of the officers connected with the Woods and Forests, the revenue now drawn for the Crown from these fisheries is very considerable, and is every year increasing in amount. The

Commissioner entrusted with this duty made most searching inquiries along the sea coasts, and also along river banks, to ascertain whether the proprietors who claim salmon fisheries there could show a legal title to them. Much irritation was caused by these proceedings; and it seems not unreasonable that, in respect of the revenue obtained by the Crown from Scotch Salmon Fisheries, the Executive Government should not grudge the expense of affording the means of additional protection.*

This is a practical question which may well be pressed on the attention of Her Majesty's Government. The Association recently formed for the improvement of Scotch Salmon Fisheries would render signal service to the country, by appointing a deputation to wait upon the Home Secretary, to urge that steps should be taken for remedying evils, officially made known to Government twelve years ago, and now attempted to be more fully explained in the foregoing pages.

* It is said, that the amount of Salmon Fishery Rents now drawn by the Crown in Scotland amounts to about £7000; and that they are annually increasing.

COARSE FISH CULTURE.

BY

R. B. MARSTON,

EDITOR OF THE 'FISHING GAZETTE,' MEMBER OF THE EXECUTIVE COMMITTEE OF THE NATIONAL FISH CULTURE ASSOCIATION.

CONTENTS.

Conference on Friday, 29th June, 1883.

Mr. Thomas Spreckley (Chairman of the Thames Angling Preservation Society) presided. In introducing Mr. Marston, he said he was a gentleman who had descended from the higher realms of piscatorialism on this occasion; for, though he was a trout and salmon fisherman, he had now come to tell them what he knew of the coarser kinds of fish, which give great pleasure to tens of thousands of their poorer brethren as anglers who could not afford to fish for trout or salmon. He himself knew very little of what was called the science of fish breeding, but he believed that no one could feel more than he did the necessity of protection for the fish. He had seen rivers where you could scarcely get a fish worth taking, and yet when he had four or five miles under his care, at the end of four years, without the aid of anything foreign, simply by protection, by having a book of rules and laws, it had been so improved that the last time he fished there he took a jack of eleven pounds, and three over seven pounds, besides smaller ones which he put back. At the same time he never refused permission to fish but once.

COARSE FISH CULTURE.

Before proceeding to give you some description of the various methods in which what are generally, but I think incorrectly, termed coarse fish may be propagated, it may be well to point out as briefly as possible the reasons why they should be propagated.

This is the more necessary because the majority of those who are interested only in the Salmonidæ, as a rule consider all other fresh water fish as useless, or worse than useless. As a trout angler myself, and much preferring that branch of sport to any other, I am perfectly ready to admit that coarse fish of almost any kind, in a trout or grayling stream, are indeed worse than useless. That there are circumstances, however, in which coarse fish are not only useful, but extremely valuable, I hope to be able in the course of my remarks to demonstrate to you.

There is a maxim, attributed I think to Jeremy Bentham, for which I have always had great respect, "The greatest good of the greatest number." I take this to mean that though a thing may not be good for all, yet if it be for the benefit of the majority its *raison d'être* is established. There are many thousands of anglers in this country, how many thousands it is difficult to say, but the fact that the vast majority of them are coarse fish anglers is beyond question. In London and Sheffield alone there are some twenty thousand coarse fish anglers enrolled as members of angling clubs, and in addition to these there are many thousands who fish only for coarse fish who do not belong to any club. I will not enlarge on this matter of the vast number of coarse fish anglers, because my friend Mr. Wheeldon is preparing an exhibition handbook on the

angling clubs of London and the provinces, and I am sure that the statistics he will give you respecting their number, nature, and organisation will astonish and interest you, and fully bear out the statement that of the two classes of anglers, those who fish for salmon and trout and those who fish for other fresh-water fish, the latter are by far the most numerous.

The first reason, then, why we should cultivate coarse fish is because they afford sport and healthful recreation to many thousands of our fellow men—the majority of them being working men who have neither means nor opportnnity for trout or salmon fishing.

The second reason is one which I think will be new to many of you, and it has the advantage of recommending itself strongly, I think, to all who are interested in the culture of Salmonidæ. This highest branch of pisciculture has been brought to such perfection that, as we were informed in the admirable paper on the subject read by Sir James Maitland last week, fully ninety-five per cent. of eggs can be successfully hatched and reared by artificial means. But to rear Salmonidæ successfully in captivity * you must feed them, and the question of food is an all important one, inasmuch as on it depends in great measure the quality of the fish and the price at which they can be profitably sold. The trout, I need scarcely tell you, is a fish of prey, provided by nature with a capacious mouth armed with rows of sharp teeth, and it is a fact well known to trout anglers that large trout feed almost exclusively on smaller trout and other fish.

I am indebted to Dr. Zenk, president of the Unterfränkischen Kreisfischerei-vereins, for the suggestion that

* By "in captivity" I mean those cases where a large number of trout are kept in a small body of water, in which they would starve unless food is provided for them.

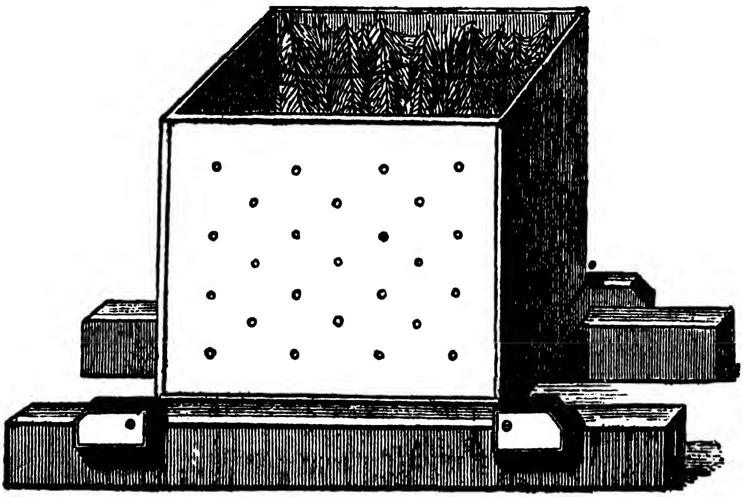
coarse fish can be most advantageously cultivated with a view to obtaining food for Salmonidæ. Dr. Zenk, who had hoped to have been present with us to-day, is the proprietor of one of the largest fish-breeding establishments on the continent, viz., that of Zeewiese, near Gemünden in Bavaria. The fishery comprises about thirty miles of water, including a portion of the river Saale well stocked with coarse fish, almost the whole of the Schondra; with many smaller brooks stocked with trout and grayling. I may mention that Dr. Zenk entertains no doubt whatever as to the possibility of breeding almost infinite numbers of any kind of coarse fish, and some of his ponds are devoted entirely to the cultivation of coarse fish for the purpose of obtaining food for his vast stock of Salmonidæ.

I will now pass on to the practical part of my subject, and endeavour to describe to you the various ways in which coarse fish, or, as they are called in Germany, summer spawning fish, may be propagated.

It must be borne in mind that it has not been found possible to cultivate these fish in the way that the Salmonidæ are cultivated. It is not only difficult to manipulate the eggs in troughs and trays, but the difficulty of rearing the young fry is even much greater. They are hatched out as perfect fish, at once requiring extraneous food, and they are so extremely small that all attempts to feed them artificially have failed. They appear to require that as soon as they leave the egg they should be able to seek their own sustenance on the almost invisible animalculæ present in their native waters. But to cultivate these fish artificially is not only difficult, but unnecessary. All that is necessary is to aid nature to a certain extent by placing parent fish in suitable places for spawning, and then protecting the eggs until the fry hatch out.

We have here some diagrams, which were kindly prepared for me by my friend Mr. Hobden, to illustrate a Paper on this subject which I read last year to a meeting of London anglers at the Society of Arts Room, on which occasion Mr. Birkbeck very kindly took the chair. The outcome of that meeting was the establishment of the United London Anglers' Fisheries Association, to which I shall refer presently, and whose objects are to obtain suitable fishing waters for the London anglers, and to stock them with fish.

This diagram represents what is known in Sweden as



LUND'S HATCHING BOX.

Lund's hatching-box. It was invented more than a hundred years ago by a Mr. Lund, of Linköping. The Swedish inspector kindly furnished me, in February last year, with information about this box, which is in general use in Sweden. He says:—"Replying to your letter of the 25th of February, in which you request me

to give you some particulars respecting Lund's hatching-box for the propagation of summer-spawning fish, I herewith hasten to give you all the information I can. Lund's apparatus is remarkable on account of its being, for aught I know, the first attempt in Europe to promote the propagation of the above-mentioned fish with human assistance. As you rightly suppose, the box is to be placed in shallow water near the bank, so that the water does not flow over it. Lund has not given any dimensions for his box, which may be of any size. The sides are hinged, so that they can be let down, and they are perforated with numerous small holes, so that the water can circulate through. The inside should be charred by fire to preserve it. The bottom of the box and the sides are lined with fir branches. As you will see from the sketch I send you, the box should rest on blocks, so as to be raised a little from the bed of the water. With some modifications—for instance it is not necessary to have the sides hinged—Lund's box has been adopted here in Sweden with success, and, in my opinion, for the hatching of perch, it is the most practical that has yet been invented. In a box of this kind, 6 feet square, and with sides 2 feet high, we place fifty female and from twenty to thirty male fish. These fish must be placed in the hatching-box as near their spawning time as possible, and are taken out again as soon as the spawning is finished. The fish deposit the spawn on the branches. It is of great importance that the sides are well perforated, to ensure free circulation of the water. We use these boxes chiefly for perch, but they can also be used, with some modifications, for other fish."

You will see, gentlemen, that it is an easy matter to transport spawn which has been obtained in this way to almost any distance, as it adheres to the boughs; so that

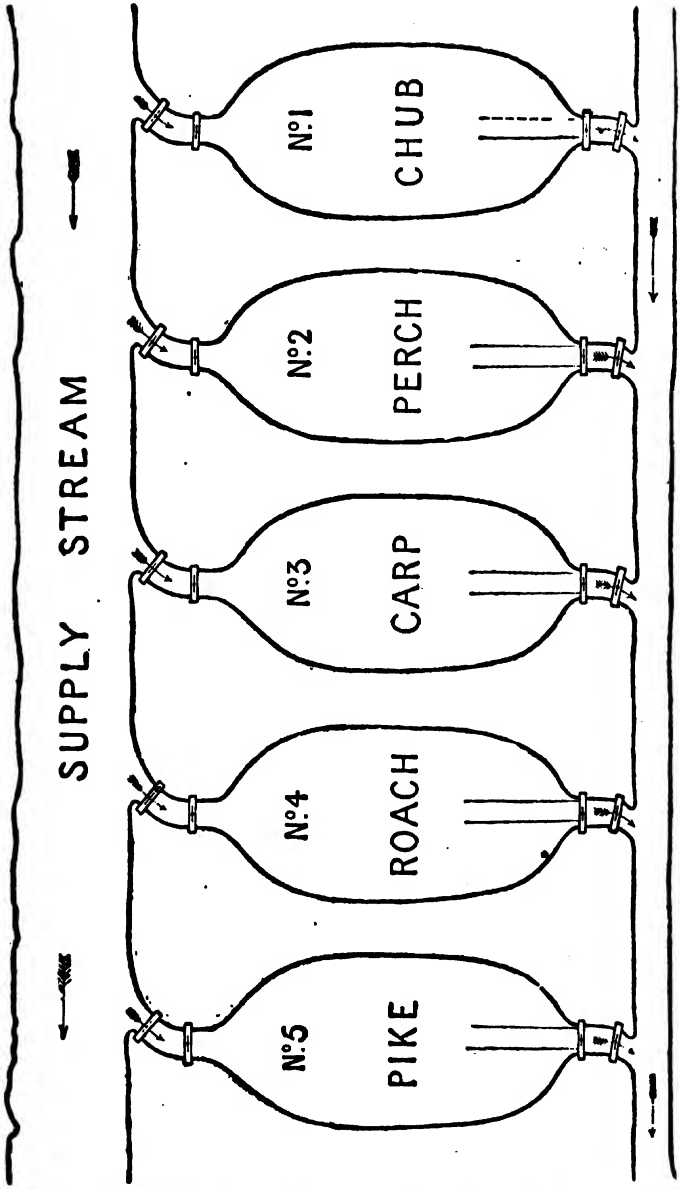
you can either let the fry develop in the box, and then go free in the water you desire to stock, or you can carry the fertilised spawn to some place, perhaps a hundred miles away, and then place it in a similar box in the water you desire to stock. In a week or ten days' time the fry will hatch out in countless numbers, and must then be liberated and allowed to begin their fight for life alone. In the Swedish exhibit in the present Exhibition, you will see some models of Lund's box. Here is one which the Swedish Commissioner has very kindly lent me to show you to-day. These models were exhibited in the Berlin International Fisheries Exhibition, and are thus referred to, in the German Official Report on that Exhibition, by Dr. Haack, director of the great fish breeding establishment at Huningen. In dealing with the Swedish exhibit he says:—"In the Swedish exhibit there were two insignificant-looking models, which were quite overlooked by the majority of visitors, but which were of the very greatest interest to every thinking pisciculturist. These models, in spite of their simplicity and insignificance, show us the way we, in future, most simply, easily, and inexpensively may carry on the propagation of our summer-spawning fish to any extent." He then describes the manner in which the box is used, and refers to its advantages as follows:—"As will be evident to every one, the eggs which have been deposited and impregnated in the box develop in a perfectly natural manner . . . air, light, and sun are able to exert their influences on the eggs in exactly the same way as if they had been deposited on water-plants in the open water in the ordinary way. Wind and waves can in like manner exert their beneficial influence on the eggs, which at the same time are protected from the violence of the storm, from which cause alone millions of eggs are frequently destroyed in the open water. The sides of the box and the branches

effectually prevent this destruction." Further, the numberless enemies of the egg are shut out, for by placing a piece of wire netting over the top, the ravages of swans, ducks, and wild fowl—those great destroyers of spawn—are provided against. When I described Lund's box to the meeting at the Society of Arts Room last year, to which I just now referred, its manifest advantages for coarse fish culture were fully appreciated, and a society was formed, of which I am glad to see we have here present to-day the President, Mr. Philip Geen, and the Hon. Secretary, Mr. T. Hoole. This society was formed with the object of renting waters and stocking them with fish, and it decided this spring to experiment with Lund's box. Six boxes were made and used, and I think I may say that in spite of some errors inseparable from a first experiment of this kind, they proved fairly successful. Spawn in large quantities was deposited in some of the boxes, and large quantities of fry were afterwards observed in and around them. The only difficulty experienced was in obtaining the parent fish, but as I trust the gentlemen who had charge of these boxes will give us some account of their experiences, I will not refer to them further than to mention that in a box the Society kindly lent me, and which I hope to make better use of next year, I placed one female perch, of about three quarters of a pound, and two very small perch. After about ten days I found a band of perch spawn containing many thousand eggs in the box, but as they remained unfertilised for want of male fish, of course they perished. I tried everywhere to obtain perch just before they spawned, but was unsuccessful. But from what I have seen of its practical working, I am perfectly assured that, provided you can get an adequate stock of parent fish, the Lund box is a most admirable contrivance for obtaining any quantity of fry.

Another, and in some respects even more simple contrivance for breeding these fish, is the breeding-hurdle. It consists of an ordinary hurdle, on which branches have been intertwined; it is sunk in a pond, lake, or stream, in any shallow undisturbed spot, and the fish find it a convenient place on which to cast their spawn, which can then be taken out and transferred to other waters, or left to hatch out. It is chiefly advantageous where natural spawning places are deficient, and is used to a considerable extent in France and Sweden.

Where some primary expense is not a matter of consideration, the next method I shall describe to you is perhaps the best and most satisfactory of all. I refer to the pond system of cultivation, which is carried on to such an enormous extent in Germany. The diagram (p. 216), most kindly made for me by Mr. G. A. Audsley, represents a small coarse fish farm, such as I venture to suggest might be most advantageously instituted by the National Fish Culture Association, for the purpose of hatching and rearing fry of all kinds of coarse fish, for distribution to angling clubs and private individuals requiring these fish. I am so often asked by secretaries of angling clubs and others where they can obtain coarse fish for stocking their waters, that I feel certain if the association was in a position to supply the fry of coarse fish in large quantities, the demand would be very large indeed. What holds good in the case of Salmonidæ will equally hold good in the case of coarse fish, for to one angler for the former fish there are a hundred anglers for the latter. It will be seen from the diagram that in the arrangement I propose each pond, although supplied from the same stream, is entirely separate from the others. The water flows from the river into the pond, and from the pond into the waste water stream. It would be almost impossible if the water flowed from one

SUGGESTION FOR COARSE FISH FARM.



WASTE STREAM.

NOTE.—The ponds can of course be of any dimensions, according to requirements—50 yards long by 25 broad would be a convenient size. The faint lines at the lower end of the ponds represent a drain as deep as the deepest part of the pond, so that all the water can be drawn off when necessary.

pond into the next, as is the case in trout-breeding ponds, to keep the various kinds of fish distinct. The fry are so small that they will find their way through the finest grating, and it would manifestly never do to send a customer who had ordered roach, bream, or carp fry, a number of young pike or perch as well! The ponds, and the amount of water passing through them, should of course be adapted to the nature of the fish to be reared in them, and only one kind of fish, or fish similar in their habits, should be bred in a pond. As an instance of what may be accomplished with coarse fish in this way, I may mention that last spring Herr Max von dem Borne, the well-known German pisciculturist, placed about five hundred carp (spawners and milters) in one of his ponds, and in the autumn, when he drew the water off before a large company he had invited to witness the result, more than eighty thousand fine young carp were found.

I have referred to the difficulty experienced in obtaining parent fish for breeding purposes; there are hundreds of streams and other waters in this country which contain coarse fish, which are considered by the proprietors of these waters as, I was going to say, vermin; at any rate, they do all they can to get rid of them, to make room for their trout and grayling. Now I venture to suggest that the United London Anglers' Fisheries Society, and the National Fish Culture Association, would find this a most profitable field to work. I am perfectly certain that the proprietors of trout and grayling fisheries would be only too glad to give these societies all the coarse fish they could catch in their waters, and the very finest pike, perch, chub, roach, &c., are those which are bred in a trout stream. The expense of netting and fish-carriers would not be great. I am led to make this suggestion because, when on a trout-

fishing excursion, I have often thought how welcome these shoals of despised coarse fish would be if transported to some of the depleted waters fished by London and other coarse fish anglers. Our worthy and much-respected chairman, Mr. Spreckley, President of the Thames Angling Preservation Society, and the other officers of that society, have done a grand work of this kind by netting the reservoirs of the water companies along the Thames and other waters, and turning their stores of fish into the Thames.

Having described the methods in which coarse fish culture may be carried on, I will now, with your permission, give a brief general account of the natural conditions under which some of these fish breed—to give a complete list would occupy too much time. In coarse fish culture the more closely we follow the conditions laid down by nature, the more likely are we to meet with success. Being fully aware of the scantiness of our knowledge respecting the breeding of many of our coarse fish, I wish to disclaim any pretension to complete accuracy in what I state respecting this matter. I have got my information, such as it is, partly from personal observation, and partly from foreign works which refer to the subject.

SPAWNING TIMES OF COARSE FISH.

Nature of places they choose, and time it requires the young to hatch out.

The Pike spawns in February and March; the eggs, which are small, hatch in from fourteen to twenty-one days, and are deposited on mud, rushes, sedges, and other water plants in shallow quiet bays and ditches. The parent fish usually go in pairs.

The Perch spawns from March to May; the eggs, which hang together in bands like rows of beads on a coral necklace, are very small at first, but gradually swell, and the young fish escapes in from ten to twenty days according to the temperature of the water. The eggs are deposited on water plants and submerged boughs, and are then fertilised by the milt of the male fish.

The Loach spawns in December and January; the eggs, which are deposited on gravel in running water, hatch out in from thirty to forty days.

The Carp spawns in May and June; the eggs are deposited on water plants, and hatch out in from fourteen to twenty days. There are three kinds of carp; the common carp, which is covered with large scales; the mirror carp, which has one row of very large scales along the back, and another along the side, the rest of its body being covered with a leather-like skin free from scales; and the leather carp in which scales are entirely absent. Specimens of the two last-named fish, which are not common in England, can be seen in the aquarium of the Exhibition.

The Tench is another powerful and handsome pond fish which would well repay cultivation. It prefers stagnant and weedy waters. Like the carp and eel it buries itself in the mud in the cold months. Its food consists of larvæ, water plants, and worms. Like carp and all other muddy-flavoured fish, it eats well, and loses the muddy flavour if kept for a time in clear running water. It spawns from May to July on water plants, and the young fish hatch out in a week or ten days.

The Gudgeon, Minnow, Loach, and Bullhead spawn from May to July, selecting very shallow streams, and depositing their eggs on the gravel and stones. These fish

all form admirable food for Salmonidæ, and can be easily cultivated in any small clear stream.

The food of the carp consists chiefly of the larvæ of water insects, worms, sprouts of water plants, and decaying vegetable matter. Kitchen refuse forms very fattening food for carp. To rear carp with the greatest success the parent fish should be placed in a suitable pond in which there are no other fish; they spawn in May and June; the parent fish should then be netted out, and in the autumn, under suitable conditions, there will be an immense crop of young carp from two to three inches in length. The carp is a powerful fish affording great sport to the angler, and its cultivation might be most profitably carried on in England. In fact before the advent of Protestantism in England fish stews for the natural propagation of carp and other fish were very common.

The *Roach*, *Rudd*, and *Bream* spawn in May or early in June on water weeds; the eggs hatch out in a week or ten days.

The *Chub* spawns at the end of April or beginning of May, on shallow sandy or gravelly places, and the eggs hatch out in a very short time.

The *Barbel* spawns on stones and gravel, in a sharp stream from one to three or more feet deep; how long the eggs take to hatch out I have not been able to ascertain, but probably in a week or ten days.

The *Dace* spawns in March or the beginning of April, also in sharp shallow streams. There are some valuable foreign coarse fish which I think might be advantageously introduced into this country; but as my friend Mr. Oldham Chambers is to give us a Paper on the acclimatisation of foreign fishes, I will only refer to one of these, viz. the American black bass, because this fish—thanks chiefly to

the great interest taken in it by the Marquis of Exeter—may be said to be acclimatised here already. There are probably many thousands of them now in the fine sheet of water called White-water, near Burleigh House, Stamford, the country residence of his lordship. In 1878 and 1879, Mr. Silk, the able pisciculturist to the Marquis, brought over from the United States nearly one thousand young bass; and he informs me that the fish have spawned the last two or three seasons. Last year Mr. Silk was sent to the States to obtain a further supply of these fish, and they were distributed among some half-dozen gentlemen who had subscribed towards the expenses of getting them over. I received thirty of this lot, ranging in size from one and a half pounds to a few ounces, and they appear to be doing very well in a small sheet of water in which I have placed them. Having for some years past strongly advocated the introduction of this fine game and food fish into suitable English waters, I was, in common with others interested in this fish, extremely sorry to see, from the reports in the papers, that Mr. Goode, the United States Commissioner, had "warned English anglers against the black bass." I felt convinced that Mr. Goode did not intend to warn us against the introduction of this fish into *any* of our waters, but only such as were suitable for Salmonidæ. Knowing that an expression of opinion on this matter from so high an authority would have very great weight in this country, I wrote to Mr. Goode to ask him if he intended his remarks to apply to the introduction of the fish generally. His reply was exactly what I expected it would be; and I have very great pleasure in reading it to you, because it will do far more to remove any prejudice against the introduction of the black bass into *suitable* English waters than anything I can say:—

Mr. Goode says :—

"DEAR MR. MARSTON,—I am much annoyed—with myself chiefly, for I ought to have expressed myself more explicitly—that my remarks upon the black bass were so misinterpreted. I was speaking solely in reference to planting black bass in salmon streams, and in comment upon Sir James Gibson Maitland's paper upon the culture of *Salmonidæ.* The entire drift of my remarks was to the effect that the black bass is a fish with which public fish-culture had nothing to do, being purely an angler's fish, and not one which professional fishermen can take in large quantities for the supply of the public markets. As an angler's fish I believe the black bass to be superior in every respect to any fish you have in Great Britain outside of the salmon family, and I believe that its introduction into streams where pike, perch, roach, and bream are now the principal occupants, can do no possible harm, and would probably be a benefit to all anglers. It is also well suited for large ponds and small lakes, where there is an abundant supply of 'coarse fish,' which a school of them will soon convert into fish by no means 'coarse.' If you will kindly refer to my 'Game Fishes of the United States,' p. 12, you will find that my views as to the value of the black bass in my own country are already on record, and I can see no reason why this fish should not be equally valuable in Great Britain. I quote from my own essay as follows :—

"'Fish culturists have made many efforts to hatch the eggs of the black bass, but have never succeeded. . . . This failure is the less to be regretted since young bass may easily be transported from place to place in barrels of cool water, and when once introduced they soon multiply, if protected, to any desired number. The first experiment in their transportation seems to have been that of Mr. S. T. Tisdale, of East Wareham, Massachusetts, who, in 1850, carried 27 Large-mouths from Saratoga Lake, N.Y., to Agawam, Mass. The custom of stocking streams soon became popular, and, through private enterprise and the labour of State commissioners, nearly every available body of water in New England and the United States has been filled with these fish, and in 1877 they were successfully carried to the Pacific coast.

This movement has not met with universal approval, for by the ill-advised enthusiasm of some of its advocates a number of trout and bream have been destroyed, and complaints are heard that the fisheries of certain rivers have been injured. The general results, however, have been very beneficial. The black bass will never become the food of the millions, as may be judged from the fact that New York market receives probably less than 60,000 lbs. annually; yet hundreds of bodies are now stocked with them in sufficient numbers to afford pleasant sport and considerable quantities of excellent food. 'Valued as the brook-trout is for its game qualities,' writes Mr. Halloch; 'widely distributed as it is, and much extolled in song as it has been, the black bass has a wider range, and being common to both cold and warm waters, and to northern and southern climes, seems destined to become the leading game fish of America, and to take the place of the wild brook-trout, which vanishes like the aborigines before civilization and settlements.'"

"I shall try to be present at the reading of your paper on Friday, but fear that I may be detained by another engagement. I shall be very glad, then, if you will quote this letter as fully as your space will allow, in justice to the black bass and its advocates, as well as to myself.—I am, sir, yours truly,

"G. BROWN GOODE,
"*Commissioner.*"

I am sure, gentlemen, nothing could be more satisfactory than this letter. As an enthusiastic angler for all kinds of fish, I should be the last to advocate the introduction of a fish which would spoil our sport. Nor would I have anything to say for it if it were a fish like the trout, affording sport chiefly to the rich; but the black bass is essentially a poor man's fish; it will take any kind of bait freely, affords superb sport, and thrives best in just those waters which are not suited to trout and salmon, viz., ponds, lakes, and slow, deep streams.

In conclusion, gentlemen, I thank you sincerely for the

patient and kind manner in which you have listened to my Paper, and I trust that some of the facts I have given you in connection with a subject which is really of vast importance to many thousands of anglers, viz., the increase of our sport-affording coarse fish, will counterbalance to some extent the deficiency of my Paper in other respects.

DISCUSSION.

Mr. J. C. BLOOMFIELD said, coming from Ireland, he should like to say a word or two upon this matter. Like the Chairman he had been for many years endeavouring all he possibly could to protect fish; and possibly there might be some present who had come across, at Lough Erne, in the north of Ireland, the results of his labours. He had been a salmon and trout fisher himself, and no one would wish to associate them with such fish as they were dealing with to-day. But he agreed with Mr. Marston that you could not touch anything that was of more importance to the country than this coarse fish question. In this country there were a vast number of poor people who visited the different ponds and small rivers for the purpose of angling, and no one would grudge them the pleasure and the exhilaration they would feel on those occasions, and which they appreciated all the more from the confined nature of their occupation during so many months of the year. The salmon fisherman who knew what it was to have a twenty-pound fish at the end of his line must be a churl if he would not like to see a ten-pound pike at the end of the line of his poorer brother. He had in his mind's eye a spot in the north of Ireland where, from one hill, you had a view of twenty-seven mountain lakes all containing pike,

perch, roach, or trout. He was not sure that it was worth preserving the trout, because, although there was sufficient running water for them to live in, they were not in good condition for the table. But of those twenty-seven lakes not five pounds'-worth of food was taken out of them from year's end to year's end. If some of their German and French friends had those lakes, what would they make out of them? The fact was there were millions of acres of water in Ireland lying neglected. A man in Manchester who took all his rabbits for two years, came over, and saw him one day drawing for bream. In one day he brought out about twelve tons. He was very much astonished, and said there were a great many Irishmen in Manchester and Liverpool and there was not one of them who, at certain times of the week and many times of the year, did not want fish, and if these fish could be sent to Manchester, he should be very glad to pay well for them. That showed the desirability of the cultivation of these coarse fish. It would be an immense benefit to numbers of poor people whose conscience did not allow them to eat meat at certain times and who could get nothing else. London was the great centre, as he hoped it always would remain, of Imperial interest, and they had all been delighted to see the interest which had been taken in this matter by their Royal Highnesses the Prince of Wales and the Duke of Connaught; but he hoped that the interests of Ireland would not be left out in the cold.

Mr. MANN, as a fish culturist from the age of fifteen, could not allow Mr. Marston's Paper to pass without offering him a tribute of thanks for the information he had conveyed. Ten years ago he should have objected that the cultivation of coarse fish was not necessary, but when he came to think of the enormous increase of rod-

fishers, the steam-launches on the Thames, and the enormous interest some people seemed to take in the introduction of swans, Brent geese, ducks, and other individuals which shovelled up ova when deposited in the spawning-beds, he was free to confess that two years ago he withdrew unreservedly his opposition, and as far as it lay in his power he should be happy to give any association with which Mr. Marston was connected his utmost support. Mr. Chambers' fish box was like Lund's, only that the sides were covered with galvanised wire, the insides being lined with the points of the pine. He remembered one day in his sixteenth year, having got tired of fishing he turned up his sleeves and went along the bank trying to catch a few cray-fish. He came to the roots of an old willow-tree, and there discovered large rods of spawn attached to and intermingled amongst the roots of the willow. He got the man who was with him to cut off the roots, put them in his bait tin, and took them home and put them into a pond through which flowed a slight stream of water. Every morning he examined these under the microscope, and was delighted to see the gradual development of the perch. The recollection of the fact suggested to him, when he saw Mr. Chambers' box, that it might be improved by interlacing the roots of the willow into the uprights of these boxes in place of the points of the pine-tree, which he thought were hardly to be found at the bottom of a river. They were very slippery, and where the point was broken off there was always a resinous flow into the water, which would at once be fatal to the germ. He had put this forward as a suggestion which he hoped would be tried. As an illustration of what swans, geese, and ducks would do he might say that there was a certain nobleman in the south of England who was kind

enough to grant him permission to fish his streams. Some years ago he came to a fine shallow and there found four swans with their heads down going along on the scour. The man who was with him said, "I am afraid you will not get any fish off there to-day;" and his reply was "No; and who is going to get any three years hence?" He drove the swans away, went in and sifted the gravel, and there was not one-tenth part of the ova left; they had gobbled it up by pints, and what was the result? Later on the same nobleman granted him a day's fishing, and, instead of catching fifteen or sixteen pounds of trout, he killed only five takeable fish, and in two years the stream would not be worth throwing a fly upon. They had heard from Professor Huxley that the destruction of man did not matter, and that nature would balance itself. He was willing to grant that with regard to the herring and the cod it might be so, but with regard to the crustacea inshore and trawl fish, which they were not now discussing, he entirely denied it from his own practical observation. He knew of one ledge of rocks on which a family could once gain a livelihood of £6 a week, and it was now not worth fishing.

Mr. WHEELDON, while thoroughly indorsing what had been said with regard to the Paper, confessed to some disappointment that Mr. Marston had not suggested some practical scheme which might be placed in due time before the National Association of Fish Culture, of which he had the honour to be on the Council. He should like to have heard of some thoroughly well-developed scheme for which they might have asked the co-operation and assistance of the Legislature. He had very little belief personally in the idea that the angling clubs of London would be the greater supporters to this scheme, because, unfortunately, however hearty

their sportsman-like spirit might be, they did not develop the great spirit of co-operation. If they did, they might be the most powerful body of men in the kingdom. There was very little doubt that the anglers would be found in overwhelming numbers compared to fox-hunters, pigeon-shooters, coursers, or any other description of sportsmen, and it was inevitable that it should be so, because in a great manufacturing country like England, it was certain that the men who had to spend their lives in hard work, would devote their leisure more frequently to the sport of angling, which had a peaceful tendency. With regard to the introduction of the black bass, he did not gather from what Mr. Goode said, that he desired it to be introduced into any body of water containing salmonidæ, because such a course would be simply suicidal. They might as well let out all the pike and perch of the Avon into some of the Hampshire trout streams, or other waters tenanted by trout, and hope to have the race of trout prosper. He recognised most fully the fact that the black bass was a grand sporting fish, and a good food fish, and a fish which might be of essential use if introduced into such waters as the Serpentine, or some of the ornamental park waters, such as the Welsh Harp and other places of like character. Why the powers that be should debar London anglers from fishing in the Serpentine and other waters of a like character, he did not know, and if they had the black bass thoroughly established, in due time they might have as many black bass clubs as there were in America. With regard to the question of swans on the Thames, he would say a word or two. The previous day he went out fishing on the Thames, and saw to his great regret, that in spite of the immense amount of damage done by swans, not only were the swans on the Thames increasing, but there were absolutely bills

posted prohibiting any one taking the eggs or destroying the young birds. Perhaps that might be necessary, but he did really think the Legislature should be asked to cause the number of swans on the Thames to be reduced to some extent, because they did an immense amount of evil. With regard to the traffic on the Thames, he hoped a bill would soon be passed in Parliament for its better regulation; but he did not think it applied exclusively to launches. No doubt they did a large amount of harm, but it was certain that every boating season, although the anglers of London have very few rights, they were certainly despoiled of them by boating crews continually practising on the Thames. On the previous day he was fishing, when an eight-oared boat of some kind came down, manned by a crew of College boys; Eton boys were grand young fellows, but they were a very great nuisance on the Thames, and to anglers generally all oarsmen were of the same character. These young fellows came down the stream, and though they were not in the way, deliberately rowed smack into the punt, nearly cut their own boat in two, broke two outriggers, and then assailed them with a volley of Eton abuse. It was quite certain the question of anglers' rights and privileges and coarse fish culture was one which ought to receive more attention.

The CHAIRMAN informed the Conference that a bill for regulating steam-launches passed both Houses of Parliament, as he had just been informed by a letter from the Solicitor to the bill. He must say he should like to see the discussion get more practical. If they could persuade the owners of waters to do all they could to produce fish for the pleasure and food of man, it would be a great thing, and his opinion was, that you could fish as much as you liked, provided you fished fairly. With respect

to Mr. Wheeldon's remarks about the swans, there were only three and a-half swans per mile between Richmond and Staines bridge, and he did not think that was a very great excess. They might do some harm of course, as they always would. He looked forward to the time when there would be a society formed, when their own keepers would have authority from the Conservancy to watch and see the boats and launches maintained a fair speed only. He remembered a good many years ago fishing in some splendid waters about five miles from Nuneaton, some hundreds of acres altogether, and saw there lots of small fish which had been taken out with the net lying on the bank dead. It was simply murder, because if that water had been preserved, it would have been a source of pleasure to thousands. He only wished he had that water under his control. If this Paper could be made more public, and the lessons it contained impressed on the minds of those who owned the waters, what a grand thing it would be. He had no hesitation in saying that he could make it pay splendidly, simply by charging a small sum for the privilege of fishing, dealing fairly with people, and laying down proper regulations.

Mr. GEEN had also listened with great pleasure to the Paper; but could not help expressing regret that it did not lead up to some practical issue. No doubt it was Mr. Marston's intention and desire that the discussion should lead to some resolution which would bear fruit, otherwise it would be like many other meetings of anglers, which left the question precisely where they found it. The first thing was, whether it was desirable to cultivate coarse fish. If it was, the next question arose, was it possible; and thirdly, if it was desirable and possible, what were the most practicable means of carrying it out. He did

not think there could be any question in any one's mind who had heard the eloquent speech of the gentleman from Ireland, who referred not only to the importance of these fish as a means of sport, but as food. As to the first point, they were told that the man who made two blades of grass grow where only one grew before, was a benefactor, and the same principle applied to those who not only provided food, but also provided another great need of the labouring classes, and that was some health-giving sport or recreation giving them absolute relaxation from the turmoil of their every day life. He did not think there was any sport within the reach of the working-classes so innocent and health-giving as that of angling, and if it were possible to stock the numerous depleted waters in and around all our large manufacturing centres, it was certainly desirable to do so. As to the question if it were possible —he could not help fancying that people who wrote and talked so much about the Salmonidæ, thought it was equally practicable to reproduce artificial coarse or summer spawning fish; but it was not so. Some four years ago, it was brought forward at a meeting of the Thames Angling Preservation Society by Mr. Benningfield, who asked him (Mr. Geen), to consider it, and it was to be brought forward at the next meeting, but to his surprise the subject dropped; but from a conversation he had had with him, the result was, that it was perfectly practicable to artificially spawn perch; but no other summer spawning fish. The reason was this, the Salmonidæ gave a solid egg, which you could handle, and send to the uttermost parts of the world if necessary; but the spawn of the coarse fish was something you could not handle without destruction. The roach, for instance, deposited their spawn with the greatest care in suitable spots; they would go up day after day with the

intention of shooting the spawn; but if the weather turned dark and cold they would go back again into deep water. Mr. Marston had said that the eggs took seven or eight days to come out; but that was not so. They came out in twenty-four hours in favourable weather,* and that was an instance which showed how impossible it was to deal artificially with these fish except perch. Still, Nature might be assisted, and if they could possibly get a series of ponds partaking somewhat of the nature of a fish farm (because small meddling never came to any good), something might be done. It was all very well to talk of fishery associations, and Mr. Marston had given the tremendous success which attended his box, but it was only a success so far, that the female was there without the male. They must have them both there, or it would not be any good, and that was very much the result with all other boxes. They must put them in the boxes, and a certain proportion would vivify; but they would come out of the holes where the water went in. The only effectual means would be a system of ponds, and it must be taken up by somebody besides the anglers of London. They might give it their support, and no doubt they would; but he should like to see the National Fish Culture Association take up the question. If they would not, what on earth were they constituted for? He hoped that Mr. Marston and others, himself included, would be able to induce the Council to take the matter up, and then the

* I doubt this assertion. I have made inquiries in various directions since I read this Paper, and the result has been to confirm my own statement. The fish do not all spawn at once, and the eggs first deposited of course hatch out soonest. I fancy this fact has misled Mr. Geen, who may have seen the eggs of a first deposit hatching soon after a second or third deposit had taken place.—R. B. M.

anglers of London must put their hands in their pockets and give them proper support.

Mr. SENIOR remarked that some gentlemen seemed to forget that the National Fish Culture Association was at the present moment only in its infancy, and although it was really established to do what they had heard should be done and must be done, up to the present it had had no possible time for formulating a scheme. He must differ from his friend who had preceded him as to Mr. Marston's paper. There was nothing easier than to criticise a paper written and read by another man, but he considered they were all much indebted to Mr. Marston for what he had done, and it was not for him to put his head into a hornet's nest by formulating a scheme for other people to pick to pieces. If there was anything which he hated more than another it was a long speech or a long sermon, and it was a very admirable rule that papers read there should not exceed half an hour. Now in his half hour paper Mr. Marston had given the result of a good deal of study; he had told them what had been done on the continent, and what had been done in this country. There were other papers which would deal with the scientific possibilities of the question of fish culture, and he thought it very wise in Mr. Marston not to attempt a scheme, but to allow scientific men of greater age and experience to put their heads together and furnish the scheme. He had been asked by Mr. Oldham Chambers, secretary to the Fish Culture Association, to apologise for his inability to be present, he having had to go down to Norfolk in order to arrange for a little excursion for the Foreign Commissioners and others to the broads of East Anglia, which teemed with coarse fish, and which he hoped some day would be stocked with black bass. The Angling Preservation Societies, the parent

of which the Chairman represented, had done a great deal towards the culture of coarse fish. Preservation meant culture to a great extent, and the splendid takes of trout registered in the Thames during the present season, of a grand total quite unprecedented, might be considered to be due entirely to preservation. There were some grounds therefore to go upon. The Marquis of Exeter had done something towards the acclimatisation of the bass, and others had acclimatised other kinds of fish. Notwithstanding what Mr. Geen had said he still believed it was as possible to cultivate the carp and tench in ponds, lakes, or rivers, as the perch. The first thing wanted was that the public mind should be educated on this question, and such papers as that now read and as had been read at angling clubs during the past winter, would prepare the ground for the seed which would be sown. The next thing wanted would be the sinews of war, and with regard to that he would only say that Mr. Oldham Chambers would be very happy to receive cheques or contributions, and it would then be for those who had subscribed to the society and supported it to complain if it did not make some progress towards realising what had been promised.

Mr. CRUMPLEN wished to add a word or two with regard to the breeding boxes which had been described by Mr. Marston, and had been used by several anglers. The Fisheries Society resolved to take up the question, and a certain number of the Lund breeding boxes were distributed. One which was tried at Ponders End had proved a perfect success, but he differed from Mr. Geen when he said it was artificial, there was nothing artificial about it beyond this, that it rendered assistance to nature; and if you gave other fish the same assistance—it might not be in a box—but if you provided proper receptacles, and placed

food for the spawn, and took care to give them what nature would give them, he had not the slightest doubt but that similar results would be obtained. To the limited extent to which the culture of coarse fish had been attempted it had been successful, and they should be encouraged to persevere. It was not altogether a question of cost; London anglers had not much to spend, and they might be careful what they spent, but if their money was well spent in an experiment which might not he successful this year, but was likely to be successful in another, he was sure they were sufficiently intelligent to be satisfied with the result. With regard to the black bass, he was not at all opposed to its introduction under certain circumstances, but until their knowledge of it was more complete he thought it desirable to proceed with extreme caution before introducing it to any large extent. His impression was that in this matter they should be very conservative, and not run a risk which at present they were not prepared for. He would warmly advocate the introduction of any fish likely to be useful, but never until it was perfectly certain that it was not going to injure the existing stock.

Dr. SEYMOUR HADEN said a very good illustration of the extreme facility with which coarse fish were bred was shown by the way in which the town of Lyons was furnished with coarse fish before the time of railways. As a boy he was well acquainted with the neighbourhood of Lyons, and in the immediate vicinity there were six lakes one above another. They were never known to have been stocked with fish by anyone, but they were treated in this way. After a certain number of years the lower lake was dragged, and the fish sent to market. The next year the lake above it was drawn, the next year the one above that, and so on until the whole six had been drawn in turn. In every case

the lakes stocked themselves with fresh *ova*, and kept the whole of these six lakes perpetually stocked with vast quantities of coarse fish, carp, bream, tench, and jack, which were taken to Lyons market, and in fact the people of Lyons had no other fish supply whatever. There must be some mistake on the part of those who said that there was great difficulty in propagating coarse fish.

Mr. BRADY, Inspector of Irish Fisheries, then proposed a vote of thanks to Mr. Marston for his very able paper, the importance of which was shown by the lengthy discussion which had arisen. His countryman, Mr. Bloomfield, had shown how important fish culture might be made in certain parts of Ireland as food for the million, and also for the recreation of the large classes of people which could not afford the sport of salmon fishing. Whatever difference of opinion there might be with regard to the difficulties of culture, there could not be any as to the importance of it as a question of food. Mr. Bloomfield had spoken of the spot from whence he could see 27 lakes; he could go to hills from which you could look on 1027 lakes, the whole of which did not provide £5 worth of food, which might be made very valuable if only there were greater facilities for transit, for after all this was the great difficulty.

Mr. WILMOT, Commissioner of Canadian Fisheries, said it afforded him great pleasure to endorse the sentiments contained in the Paper. If anything, it was more desirable to cultivate coarse fish than the higher orders, for, speaking from an experience of 16 or 18 years, the higher orders of fish could not exist without the lower orders. The Almighty, in His providence, had thought proper to put into the same waters fish of high order and of a low order, and it was invariably

found that the high order lived on the low order. If the latter were exterminated, the former would disappear. All the finest salmon rivers had in them certain species of fish of a very low order; they entered the river at a different period to the salmon, to reproduce their species, and the young went down the rivers to the sea, and there in turn were fed upon by the salmon which frequented the same river. It was said by some gentlemen that you could not produce the lower orders of fish, but he maintained that you could produce a thousand to one of the lower orders, because they deposited their ova in the spring months, when the weather was warm, whilst the higher orders deposited theirs in the autumn months, when the weather was cold, and took from three to six or seven months to reproduce, whilst the lower orders were hatched in from three days to three weeks. Consequently nature had given the lower orders the greater preponderance. Throughout nature, as a rule, the lower orders supported the higher, and therefore it became the duty of man to carry out that which Providence had ordained. Carp was a poor man's fish altogether; it could be produced in ponds and small preserves, and ought to be protected and cultivated almost above every other, whilst the salmon and trout were the rich man's fish, because those who sought them had to spend a large amount of money on the sport. With regard to bass, it was a very bad voracious fish to introduce amongst others of a better quality, and he said this coming from a country where it was more famous than in any other part of the world. Where they found the black bass they never found the salmon or trout. There were lakes innumerable in Canada, where the bass, the pike, and other fish of the same character abounded, but they never found in those lakes any of the higher orders of fish. There were

also magnificent rivers, teeming originally with salmon and trout, and they never found black bass in them until lately, when, in consequence of man having killed all the salmon and trout, black bass had been introduced, and in consequence there was nothing but black bass there now. Black bass was a good game fish and a food fish, but they should be put into waters by themselves, or where there was plenty of inferior fish for them to feed upon, but not where they could interfere with better kinds. There was a lake in Canada which teemed with black bass, pike, perch, sunfish, and other of the lower orders, and being a small lake, the temperature in summer was 80° to 90°, and there the black bass abounded; but the inhabitants fished it to such an extent that they exterminated the bass. A petition was sent in to the Legislature about it, and an order was passed that there should be no netting for three years. When that period expired there was an abundance. No one was permitted to spear in it or to net; none but anglers fished it, and there was abundance for all. You never could destroy fish by angling, but in one year they could be destroyed by netting. Still it was no use for an intelligent man to read such an instructive Paper as they had heard to-day, or for other people to discuss it, if men of science, holding the highest positions in the country, told them that it was useless to protect the fish, and that they could take care of themselves. He could only say, if such views were to prevail, the time would come when there would be no fish in Great Britain or any other part of the world.

The resolution having been carried unanimously,

Mr. MARSTON, in reply, said there was no intention whatever to introduce the black bass into trout or salmon streams, any more than they thought of putting the pike

into a trout stream; but there were thousands of acres of water where there were no fish at present, where bass could be put, and would afford magnificent sport. The Sheffield anglers had to go about 30 miles to get their fishing, and every year paid about £15,000 for it, when they might have abundant fishing in their own neighbourhood, if only the streams were populated. With regard to the point mentioned by Mr. Mann, he believed that pine branches were used because they were found to answer admirably, and did not rot; but his suggestion was a very good one, and he hoped next year to try it. Mr. Wheeldon and Mr. Geen had been somewhat disappointed that he had not set forth a more complete scheme, but the scope of this Paper only allowed him to give an outline of the subject. He took it that they considered the matter even more urgent than he did, and no doubt they would help to formulate a scheme and support it. Mr. Geen was right, to a certain extent, in saying that coarse fish could not be cultivated artificially; but in his Paper he had insisted on this fact, and had referred particularly to pond culture, by which means any of these fish could be cultivated. Carp was cultivated to a great extent in Germany, and fetched more money even than sea fish, but he believed other kinds had not been cultivated there, because they were not wanted. There were not many anglers in Germany, and it was for anglers principally that he suggested these fish should be cultivated.

Mr. CROSSMAN moved a vote of thanks to the Chairman, who had been the principal agent in persuading the Conservators of the Thames to prevent the capture of small immature fish. Mr. Wilmot had referred to the opinion expressed on the platform by a gentleman high in the scientific world, but he would say that the great object of

these conferences was to bring together men who were not only scientific but practical, to hear their opinions expressed in the boldest manner possible, so that they might be able to arrive at the truth with regard to any subject connected with fisheries. The salient points in connection with all the fisheries would be thoroughly considered by the most competent men, and he trusted the results would be of the most practical kind. Whoever stood on that platform, whether he were a scientific man, a practical, or a theoretical man, would not, he hoped, be afraid of expressing his opinion on any subject, however antagonistic it might be to the one which seemed to prevail at the moment, because in the end the truth must prevail. The subject brought forward by Mr. Marston was one in which he had taken a great interest, and he might say that the only prize offered at the Exhibition for the cultivation of fish in fresh-water ponds was offered by himself. He saw in Germany and Austria the importance of that cultivation, and in all these matters history seemed to repeat itself. They knew that the ancient Romans were famous for fish culture in ponds. Their tables were provided with carp and every kind of fresh-water fish, and so valuable were they that it was said that one of the fish-ponds of the poet Lucullus actually realised £20,000 after his death. Dr. Seymour Haden had shown what was actually carried on in Lyons, and the same system could be adopted in this country. Wherever there were low-lying meadows, with streams or rivulets running through them, these ponds could be easily constructed. The monks in the olden days, who knew how to place their abbeys in the most lovely spots in creation, also knew which were the most valuable fish, and they always had carp ponds, because they knew it was about the best fresh-water fish, the one most tenacious of life, not carnivorous, but living on weeds and insects. There were

in this country canals of several miles in length, and numerous lakes, utterly devoid of fish, and there were ponds in nearly every field which could, under a wise system, be stocked with fresh-water fish. He was sure this Paper would draw the attention of those who took an interest in these matters to the necessity of cultivating these kinds of fish, and there was no country in the world where it could be cultivated to a more profitable extent than in England, Scotland, and Ireland.

Mr. C. E. FRYER seconded the motion. He did not wish to import a note of discord at the last moment, but he could not miss the opportunity of saying that Mr. Wilmot seemed to have slightly misunderstood the position which Professor Huxley had taken with regard to the question of fisheries. He did not come there as the apologist or defender of Professor Huxley, who was perfectly capable of taking care of himself, but it was most undesirable that any misconception should exist. Professor Huxley held the opinion that, as regards the power of man to interfere with fisheries, they were divisible into three distinct classes; those which might be destroyed, those which could be partially destroyed, and those which we have no proof that it was possible for man to destroy. With regard to the special subject under discussion to-day, Professor Huxley joined the National Fish Culture Association on the ground that it would afford the opportunity of taking up fish culture, more especially with regard to fresh-water fish, that branch being more susceptible of assistance than deep sea fisheries; the fresh-water fish would come under the general category of fisheries that were capable of being destroyed; the littoral fisheries would come under the second category, which it was possible for man to interfere with and seriously injure, if not altogether to destroy, such, for instance, as Lobster, Crab, and Oyster fisheries, and

with regard to Lobster fisheries, Professor Huxley had himself within the last year recommended that very stringent regulations should be enforced on the coast of Norfolk, in the hope that, all the circumstances being very favourable, some general idea might be arrived at as to the effect of restrictive legislation, whether it was really beneficial or not. Coming back to the subject of the Paper—or rather to the discussion upon it, for he regretted he had not been able to attend early enough to listen to the Paper—it appeared to him they should walk before they ran, for before taking up difficult and intricate systems of ponds and boxes, and apparatus of various kinds, a great deal might be done by inducing the owners of fish-ponds to treat those fish-ponds exactly as they found them;* not

* I regret that Mr. Fryer was not present in time to hear my paper because he would then have seen that my object in advocating coarse-fish culture is, that we can only by this means re-stock the rivers, canals, lakes, ponds, &c., which have been depleted by unfair fishing, over-fishing, and poaching. It will not much assist the thousands of working-men anglers if those gentlemen who have ponds cultivate them again in the way their ancestors did, as referred to in my Paper; how will that help the many thousands of club anglers? They find it usually most difficult to get permission to fish in a private pond, which is often not worth fishing; it would be more hopeless still if the owner of the water had spent money on it in cultivating it. Nor will I admit that the Lund-box, the hurdle, and the system of ponds I described can in any way be fairly designated "intricate." Their simplicity is obvious, for they merely aid nature. Finally, it will be seen Mr. Fryer recommends the German pond system, which in my Paper I had referred to as being by far the best way in which to cultivate coarse fish of all kinds, where some primary expense was not an object (see p. 215 *et seq.*). Of course I do not suppose Mr. Fryer intended to knock my skittles down merely to set them up again himself in this way; but I think it was a pity he deprecated my suggestions without having heard what I had said about them, and then proposed as a substitute the very thing I had advocated most strongly—except that my pond farm would be less "intricate" than those he proposed. I proposed one pond for one kind of fish; his suggestion would require three ponds for each kind of fish.—R. B. M.

to leave them fallow, and utterly ignore them, but to cultivate them as they would a field. A man who owned a field did not leave his sheep and cattle to run wild and starve, but fed them, and killed them when necessary; so with fish, a man who owned a fish-pond had a source of food supply which was inexhaustible if properly managed. Fresh-water fish were not like salmon; salmon lived in the sea, and in the head waters of rivers, but coarse fish were always on the spot. You had a pond with fish in it, and they did not want to run away; they were not eels who climbed out and ran over the grass. They would remain there and breed and fatten if properly treated. Without going minutely into the question, he might throw out the suggestion that gentlemen having ponds should, without going to any great expense—for the idea of expense and scientific apparatus frightened many people—endeavour to cultivate the fish as they found them, dividing the pond into one or two portions, keeping the breeding fish in one portion, the yearling fish in another, and fattening and feeding them in another. They might be netted if thought desirable, only taking care that a proper proportion were left for breeding. In saying this he did not wish to throw cold water on any scientific attempt to increase fresh-water fish in any way whatever, because the further they went in making scientific and practical investigations in this matter, the better it would be in the end; but without going to the trouble of making special ponds and apparatus, many gentlemen had the opportunity of doing a great deal towards increasing the food supply, simply by utilising the stock of fish they had in their own private grounds.

The resolution having been carried unanimously,

The CHAIRMAN in responding said it was a fair answer

to a great deal that had been said, that a few years ago between London and Staines scarcely a fish was to be caught in the Thames. This year there had been the finest takes of trout ever known. Within the last fortnight more fish than ever had been taken in the Thames. This was accomplished simply by preservation, care, and attention. He hoped the time would soon come when children would be taught not to kill young fish, just as they were taught not to kill a calf or a lamb directly it was born.

THE DESTRUCTION OF FISH

AND OTHER

AQUATIC ANIMALS

BY

INTERNAL PARASITES.

BY

T. SPENCER COBBOLD, M.D., F.R.S., F.L.S.,

CORRESPONDENT OF THE ACADEMY OF SCIENCES OF PHILADELPHIA.

CONTENTS.

Conference on Thursday, July 12, 1883.

Professor Huxley, P.R.S., in the Chair.

THE DESTRUCTION OF FISH AND OTHER AQUATIC ANIMALS BY INTERNAL PARASITES.

This communication is not intended to be an exhaustive memoir. The subject is a wide one, yet it may with truth be said that few persons are aware of its importance. As regards man and the higher animals, physicians and other professional persons have a direct interest in conducting researches amongst the parasites; nevertheless, it is surprising to what an extent mere prejudice has operated to prevent labourers from entering into this instructive field of comparative pathology.

Taking a comprehensive grasp of the study of parasites it will be readily admitted that the extent of the subject is in itself rather appalling. If you consider that for every known species of bird, beast, reptile, and fish, acting as "hosts," there are probably, on the average, not less than four times as many different species of "guests" liable to occupy their bodies, you will then gain some adequate notion of the zoological difficulties of the study. If, further, you will consider that by far the larger proportion of all these parasites undergo transformations, often of a complex

character, and accompanied by a change of hosts, you will realise the practically illimitable extent of the territory that remains to be explored. And if, added to all this, you contemplate the kind of occupation and sacrifices demanded by researches of this order, you will, perhaps, not be altogether surprised that so few scientists have troubled themselves about the entozoa of the lower animals.

Notwithstanding that so little has been done, sufficient evidence can be brought forward to show that grave injuries, and even death itself, result to "hosts" of every degree; but it does not follow that proofs, which to the eye of the practised helminthologist are clear and convincing, will have due weight with those who are new to the subject. No person unfamiliar with the working of parasites, and with the appearances presented on dissection, is in any position to form a correct conclusion. The scepticism which prevails respecting the *rôle* of parasites in professional quarters is painful to the last degree.

When recently at the Royal Society, Professor Huxley communicated his instructive paper on *Saprolegnia ferax*, I felt tempted to rise and speak as to the parallelism which subsists between the injurious action of external and internal parasites relatively, whether animal or vegetable. As I refrained on that occasion, I was the more gratified by the opportunity recently afforded of incidentally calling the attention of the Congress to this subject.* Whilst the fullest attention has been paid to the parasitic fungi, little or no regard has been paid to the entozoa or internal animal parasites. As a matter of fact all the Salmonidæ —not to speak of other families—are liable to be largely invaded by entozoa, but it is hard to say to what extent

* See Reports of the Conference on Fish Diseases given in *Land and Water* for July 7, 1883, p. 11.

any one of the sixteen species known to infest the salmon is capable of inflicting injuries upon this valuable fish. Mere size of any given entozoön affords no criterion of its power for mischief. Amongst quadrupeds even the largest hosts succumb to comparatively small helminths. We see this in the case of flukes causing *rot* not only in sheep, cattle, and deer, but also amongst elephants. In all such cases death is primarily due to over-crowding. As in our big cities overcrowding causes the territory to suffer, so likewise the passages, ducts, and channels of any vital organ of the animal "host" suffer from the multiplication of parasitic residents. Amongst fish, flukes work little harm, since they rarely occupy any vital organ, nevertheless with cetaceans the case is far otherwise. Mammals adapted to enjoy an aquatic existence, and having an organisation otherwise conforming to that of quadrupeds, do not escape injury from flukes. To what extent they suffer is another question. I have dissected a porpoise whose liver ducts were extensively diseased, precisely as in cases of *rot* occurring in their mammalian brethren of terrestrial habits. The new species of fluke which I thus discovered in a Firth of Forth cetacean has since been found by Dr. Anderson in the Dolphin of the Ganges.* This small parasite occurs in prodigious numbers.

Save in exceptional instances, overcrowding, as before remarked, lies at the root of all injury to the host, be it bird, beast, or fish. With fish the tapeworms are most destructive. Much depends upon the situation of the parasite. When one finds the pancreatic cœca stuffed with tapeworms, choking not only these appendages, but

* Details are given in my paper on 'Trematode parasites of the Dolphins of the Ganges.' Journal of the Linnean Society for 1876. Zool. Div., vol. xiii., p. 35 (with illustrations).

at the same time extending into, and well nigh obliterating the lumen of the intestine, it seems absurd to suppose that such a victim can be in the enjoyment of good health. Physiology teaches us that sooner or later the host must succumb to this permanent interference with the functions of digestion and assimilation. If the fish does not die in a direct manner from inflammatory action, it becomes so weakened that it readily falls a prey to other enemies. To be permanently successful in the struggle for existence, all the vital powers of the individual must be maintained in good working order.

As a straw shows the way the wind blows, so do facts that are in themselves sufficiently trifling tend to produce instructive conclusions. One of my early experiences in this matter made a lasting impression upon my mind. Some thirty years ago—at the time that I held office in the Edinburgh University Anatomical Museum—I noticed in a rivulet near Musselburgh, a minnow moving slowly in the water. It seemed burdened, as I supposed, from a superabundance of roe. Having captured it with the hand, I opened the abdomen, when, to my astonishment, there was no roe at all, its body being abnormally distended by a large tapeworm. Here, therefore, was an instance where, to say the least, much inconvenience had resulted to the host, not, be it observed by overcrowding from many parasites, but from excessive distension by a single entozoön. I have since witnessed similar effects in other animal hosts widely differing in the zoological scale. Thus you may sometimes capture earwigs with enormously swollen bodies, due to the presence of a nematode that is eight or ten times as long as the host itself, and it is not uncommon to find other insects similarly affected. I will mention another curious example occurring higher in the

scale of vertebrates. On one occasion when walking in the Zoological Gardens, near the elephant house, an unduly distended mouse was labouring to cross the path in front of me. Having easily killed it, I thought to obtain some embryo mice; albeit in this I was disappointed, or, rather, perhaps, gratified, inasmuch as the dissection soon revealed the fact that the distension was entirely owing to the presence of several large filariæ within the stomach. (*Spiroptera obtusa*, Rud.). Clearly these parasites had seriously incommoded the little rodent's progress, and, as in the case of the minnow, had led to its capture and death.

But I now proceed to direct your attention to far more cogent evidence, the value of which will be better understood if I first explain the special character of the tapeworms that are so injurious to fresh-water fish. The tapeworm of the minnow just alluded to was an immature ligule. All the ordinary ligules of our fresh-water fish are temporary residents awaiting their passive transference to the body of some higher, definite, or ultimate host. This final host is usually a water bird, which, preying upon the fish, swallows the parasite, and after a very short space of time the parasite itself arrives at sexual maturity. As long as the ligules remain in the fish their development is not complete, but when once subjected to new and suitable conditions their arrival at maturity is only a question of time. If the new residence is unsuitable to the species of parasite, no further development will take place; in other words, all parasites requiring a change of hosts must have an environment specially adapted to their individual wants.

With the structural changes thus brought about we are not now concerned, but it is worth while remarking that

the question of injury to any fish or other aquatic host is in no way bound up with the mature condition of the parasites themselves. I mean to say that a parasite may, under certain circumstances, prove dangerous at any stage of its life. Now, in the case of fish, it happens that imperfectly-grown tapeworms are more mischievous than the adult parasites. The ligules infesting our fresh-water fish have received different specific names, but most of them are referable to one and the same cestode. The *Ligula simplicissima* of the minnow is the same as the *Lig. tincæ* of the tench, and as the *Lig. abdominalis* of the roach and other species belonging to the genus *Leuciscus*. It is also a mere synonym of a dozen other differently-named ligules found in the carp, pike, perch, bream, goby, char, and so forth. Of especial interest is the fact that this entozoön is sometimes described as *Ligula edulis*, referring to the circumstance that it is an edible parasite. More than half a century back Rudolphi remarked that ligules were eaten in Italy, and his words lead one to suppose that they were regarded not only as great delicacies, but were freely eaten under the name of *macaroni piatti*. In my recent account of a ligule infesting the human body (*L. Mansoni*), read to the Linnean Society, I have referred to Rudolphi's original words, which have also been freely quoted by Diesing, Duchamp, and other helminthologists. Thinking that possibly there might be some mistake in our interpretation of the passage in question, I have, within the last few days, sought to ascertain on what authority Rudolphi based his remarks. Thus in Ferrusac's 'Bulletin des Sciences Naturelles' for 1828 I found an abstract of a Paper by Briganti in which it is stated that the entozoa received the name of *Ligula edulis* "because certain persons eat it fried with the fish, regarding it as a kind of fat of the

latter." This puts a very different complexion on the matter, seeing that the true nature of the alleged delicacy must have been overlooked by those at least who first partook of it. Stimulated to further enquiries I sought and found Signor Briganti's original memoir in the Transactions of the Royal Academy of Naples, bearing the date of 1819, but probably issued somewhat later, since the work by Rudolphi, from which I have quoted, bears the same date. Be that as it may, Briganti remarks that he does not think it need occasion any surprise that the *Ligula edulis* "eaten with relish by not a few with the fish which contains it," causes no injury whatever to their health. He further remarks upon the not unpleasant flavour possessed by the ligules, of which he had been assured, and says that he willingly accepts that view, because the parasite is destitute of any alimentary canal and does not contain any excrementary matters. He refers to the nourishment derived by the parasite from the juices of the contiguous viscera of the host and to other circumstances ensuring its cleanliness. Briganti's memoir, though often quoted second-hand, seems to have been rarely consulted. He gives excellent illustrations. In his first plate he figures three fish of nearly the natural size; one showing the characteristically swollen abdomen, especially in the region of the vent, and another with the viscera exposed to show the position of the ligules. In the second plate excellent figures are given of the worms in various positions, from different media, the first six examples being all removed from one of the fish (*Cyprinus lacustris*). This small Cyprin inhabits Lake Palo, near Contursi, and it was at the time regarded by Briganti as new to science. I have thought it might be useful thus to particularise Briganti's labours, although it is to Dr. Duchamp's recent work that we are principally indebted

for the most solid contribution to our knowledge of the Ligules.*

Writing in 1876, M. Duchamp observes: "During the last seven or eight years a veritable plague has overwhelmed the fish in the ponds of La Bresse, afflicting exclusively the Cyprins and especially the tench, whose deaths may be reckoned by hundreds of thousands. From such a total it will be readily understood, without commentary, what serious losses the country has sustained. It was soon discovered," he says, "that the author of the disaster was a tapeworm lodged in the peritoneal cavity of the fish outside the intestine. Since then, the *white worm of the tench*, for so they call it, has been well known to salesmen in our markets, but no one thought of troubling himself about its zoological history."

From what follows in the text of M. Duchamp's work we gather that until the time in question no notice had been taken, or at least not recorded, of the existence of these parasites. "If they had been encountered, the numbers were so restricted that the fact was passed unnoticed." All at once these parasites appeared in such abundance that they caused terrible ravages amongst the occupants of the ponds, and severe losses to commerce. "Two years ago," adds M. Duchamp (i.e., in 1874), "the malady seemed to be on the decrease; to-day, however (1876), the ligules are so common that we have had no difficulty in procuring them; and, unfortunately, in our country they have not yet arrived at the degree of rarity attributed to them by helminthologists. Whatever may have been their frequency they have remained quartered in the ponds that are encoun-

* 'Recherches sur les Ligules,' par G. Duchamp, M.D., &c. Paris, 1876.

tered at every step on the marshy plateau of La Bresse, and they have principally infected those to which by preference aquatic birds repair, especially ducks, which one meets with by thousands. So far as we know, the parasites have never been found in either of the rivers of this region."

After remarking upon the variable number of parasites found in each fish—commonly four or five, but sometimes as many as fifteen—M. Duchamp continues: "As will be easily understood, the presence of such guests in the midst of delicate organs could not fail to produce a series of morbid phenomena and to give birth to grave anatomical complications. Also, with a little practice, it is easy to diagnose the existence of the ligules, unfailingly. The abdomen of a tench bearing these parasites presents an unusual development, a true tumefaction (*ballonnement*). On applying the index-finger to the lower surface of the body between the pectoral and abdominal fins, an evident fluctuation is felt. At the opening of the abdominal cavity there escapes a noticeable quantity of liquid which is sometimes strongly sanguineous, sometimes thick and purulent, but in both cases always carrying with it large white flakes."

After remarking upon the coagulable character of this fluid and upon the leucocytes, blood corpuscles, and other elements shown by the microscope, Dr. Duchamp observes that "the intestinal circumvolutions, the ovaria and milt glands form a single mass, in the centre or near the surface of which the ligules are found often shut in by peritoneal bands." It is added that the peritoneum is thickened and covered by a layer of false membranes, but there is no trace of inflammation of the liver. In short, the affection produced by the parasite is, according to Duchamp, a veritable *chronic peritonitis*.

The progressive stages of the disease were watched in aquaria. Pathologically they are of great interest. In the anal region a rounded projection makes its appearance, augmenting rapidly in volume until it attains the size of a small nut. It then presents all the external characters of a cyst limited by a more or less transparent membrane deprived of scales, and on whose surface blood-vessels ramify. At the end of some days the cyst ruptures, and the ligules escape by the opening. As to the fish, it does not survive the accident. Such, according to what we have ourselves seen and from the accounts of the fishermen, is the ordinary mode of termination of the malady in our country. Often enough, however, the tench die without any rupture. In this case it is probable that the ligules become free only when a portion of the flesh has become destroyed by decomposition. They may, indeed, live a long time amidst such surroundings. We preserved some for several weeks in rotten fish, and they were still quite alive when we were obliged on account of the stench to stop the experiment. It is a curious circumstance that, on the other hand, those which we saw escape by the opening of the cyst succumbed in a few hours on finding themselves in the water taken from the Rhone, and frequently renewed. One of them, of which a portion remained held within the abdomen of the fish, presented the singular phenomenon of one part of the body being dead whilst the other was living. According to certain observers other parts of the body, besides the abdominal and anal regions, may equally afford means of exit for the ligules. Thus, Block sometimes saw them escape by the belly, sometimes at one of the sides, at the back or at the head, and sometimes even in the region of the tail. The wound left by the worm is oblong like that of an open or bleeding vein.

The same facts were observed by Goeze, who figures one of these instances; but according to him, the wound heals and the fish does not suffer—statements which were confirmed by Rudolphi." This happy result of course shows that in some cases Nature is capable of effecting a complete cure. In reference to what M. Duchamp has observed respecting the vitality of tapeworms in decomposing flesh I have seen much to confirm his record; and, as I have already stated in the pages of *Land and Water*, the specimens of *Triænophorus* (shown by me in this Exhibition) were removed alive by Surgeon-General Day from the stomach of a pike which had already been dead three days, and which, moreover, had been soaking in spirit for twenty-three hours! An old writer has, indeed, alleged that tapeworms can resist the action of boiling water; but modern experiments have entirely disproved the truth of a statement which can only have resulted from imperfect observation. The supposition of Dr. Fock of Utrecht, that persons obtain the broad tapeworm (*Bothriocephalus*) by eating bleak (*Leuciscus alburnus*) is not confirmed. Nevertheless, the observations of the late Dr. Bertolus render it more than probable that the *Ligula nodosa* infesting the trout is the sexually immature condition of our human *Bothriocephalus latus.* Professor Leuckart long ago pointed to the Salmonidæ as the probable source of the broad tapeworm; but the statement recently made to the effect that pike or jack are a source of these parasites requires confirmation.*

Sometimes ligules infest the muscles in great numbers. The following is a remarkable instance, and refers to the

* See the new journal entitled 'Health,' for April 20, 1883, p. 17. The statement is made on the authority of Dr. Braun.

specimens (marked No. 9) in my series of parasites in this Exhibition :—

On the 30th April, 1880, I received from Mr. Robert J. Simpson some interesting parasites, together with portions of the skin, gills, and muscles of a lake trout. The specimens were accompanied by a letter, written from Ambleside, only the day before, and in it Mr. Simpson records the following particulars :

"On Tuesday last a dead *Salmo ferox* was found in the river Brathay, a female fish, in good condition (for a spawned fish), twenty-four inches in length, four pounds in weight. The fish had evidently died from the salmon disease, though this is the first victim yet seen in the rivers running into Lake Windermere. On making a *post mortem* examination I found the fish, I may say, one mass of parasites, all seemingly of one kind, and, from the egg, as minute as can be seen, to worms two inches long. One of the gills was diseased ; the part I have cut off and enclosed in bottle. I also enclose a piece of skin, that had the salmon disease ; also a lot of the parasite at its different stages of growth. To my surprise, in cutting into the flesh under the diseased skin, I found the parasite at fully one and a half to two inches in length. I enclose one bit of skin and flesh with a large parasite in it. I hope you will be able to see it. When put into the spirit its white body was clearly seen, stretched at full length, in the pink flesh. On cutting into the flesh, and examining it more thoroughly, I found the whole flesh, more or less affected with the parasite, some at full length, others in cells curled up. I have not hitherto met with this parasite, nor have I had a specimen with the salmon disease to examine. I have not heard whether this parasite is common to fish killed by the disease. Do you know this

parasite? Can it have anything to do with the disease? The cause of death did not appear clear, looking only at the head, gills, throat, and heart, as, with the exception of the bit of gill sent, these organs seemed right."

On May 1st, and again on the 3rd, I submitted Mr. Simpson's specimens to microscopic investigation; and although neither the long "white body" in the muscles, nor a similar filamentous band two inches in length, and loose in the bottle, turned out to be tapeworms, it was soon perfectly clear that the mass of parasites from the "flesh" were cestode worms. Some were in capsules, whilst others had been liberated, but all, whether encysted or free, were sexually immature.

The examination, in fine, led me to conclude that the parasites were very young examples of *Ligula digramma*, and as such, immature specimens of the *Ligula monogramma* of water-birds. It would seem from M. Duchamp's experiments that after transfer to the ultimate host their arrival at maturity is excessively rapid, an interval of four hours being sufficient for the formation and perfection of the eggs of the parasite. Here, however, I am chiefly concerned to remark upon the circumstance that although Mr. Simpson's lake trout was suffering from *Saprolegnia*, that external parasite was not alone the cause of death. I believe that the larval ligules were in this case the chief cause of the fatal issue. The number of ligules was something extraordinary, and the fish must have succumbed if there had been no *Saprolegnia*. Judging from the sections sent, every part of the great lateral muscle-mass seems to have been stuffed with the larvæ, precisely as one finds measly beef and measly pork overloaded with *cysticerci*. Clearly it follows that if a diseased fish of this kind were devoured by one or more water-birds, the avian host or hosts would

in a very short space of time become overloaded with tapeworms. If it be further asked how the fish in Mr. Simpson's "find" became so charged with parasites in the larval state, my answer is that the fish either actually swallowed part of a dead or dying water-bird charged with mature ligules, or, what would come to pretty much the same thing in the end, it must have swallowed one or several mature tapeworms which were either discharged by the bird, or were seized whilst still remaining suspended from the avian host when swimming on the water. In either case the swallowing of the mature tapeworms would liberate the ciliated ova or embryophores. From the stomach of the fish the six-hooked embryos would bore their way through the walls of the viscera, and then, having gained access to the great lateral muscles, they would rest there to undergo those metamorphoses through which all the tapeworms pass prior to their passive and final transfer to the body of the ultimate host. The disease thus produced I have called *ligulosis*, whilst the flesh of fish so affected may in common language be said to be measled, in the same sense as we employ the term to indicate diseased beef and pork from analogous causes. The term "cestode tuberculosis" suggested by Leuckart, is not I think sufficiently distinctive; it is even perhaps misleading.

One of the reasons why many intelligent observers practically deny the powers of entozoal parasites to produce epizoöty amongst fishes lies in the circumstance that they do not often find heaps of dead fish lying on the surface of open waters. They forget how soon, in the struggle for existence, the weaker members of a shoal are cut off by the numerous enemies that prey upon them, whether these be sharks, or porpoises and dolphins, or again, fish-eating birds. Another circumstance which I am

free to confess is more liable to mislead is the evidence often presented to us of fish swimming about in apparent activity whose bodies, nevertheless, contain many scores, or even in the case of minute entozoa, many hundreds of thousands of parasites. To my mind, however, this only proves the truth of a conclusion long ago forced upon me by evidence. This may be cast in the form of a definite proposition, as follows:—"Fish can sustain a relatively greater amount of parasitism than any other animal belonging to the class of vertebrates." That is a proposition which will, I think, long hold its ground, but in the face of the facts already adduced it is impossible to deny that, even in fish, parasites may be sufficiently numerous to bring about a veritable plague or piscine epizoöty.

I quite agree with Professor Huxley that an undue "fuss" has been made about the nematodes so common in mackerel, cod, herrings, haddocks, whiting and so forth. For many years past I have been favoured with letters on this subject, and I believe that in Denmark such affected fish are rejected at the markets. On the other hand I was told the other evening, by Prince Louis Lucien Bonaparte, that in the Basque provinces *filariæ* are actually collected and eaten under the notion that these parasites are young eels, which have found their way into the bodies of fish that have thus become as it were their foster-parents! It is curious to notice the strange delusions under which continental peasantry everywhere labour. I have remarked the same error of interpretation in England regarding the supposed eel-nature of the lumbricoid parasites of man and quadrupeds; but for one of the most instructive delusions of this order we must repair to the South of France, where to this day, I believe, the large entozoa that occasionally sweep off the wolves of

the Pyrenees by epizoötic disease, are regarded by the peasantry as serpents. In helminthological circles it is generally understood, in accordance with the views originally promulgated of Küchenmeister, that the fiery serpents of Moses were nematode entozoa, or guinea-worms. It was the lamented Russian traveller, Fedschenko, who proved that fresh-water crustacea were the intermediate bearers of the Dracunculus. The boring or tunnelling of the Dracunculus is, in itself, not more remarkable than the boring of certain parasites of fish. I have dissected several examples of the sun-fish, and I shall never forget the first monster (*Orthagoriscus mola*) which came under my observation. The huge liver might almost be said to have formed a mere bag of worms. Hour after hour I tried to dissect out some of the *Tetrarhynchi* or *Gymnorhynchi* (as Professor Goodsir termed them), but they were inextricably twisted one within another. To get out some twenty inches of unbroken strobile was all that could be done. In another, and quite a young fish, the lateral muscles were even more infested than the liver itself; but judging from what has been recorded by others, this muscular parasitism in the sun-fish is exceptional. Be that as it may, it is my firm belief that injuries to the vital organs of fish, such as I have repeatedly witnessed, cannot be produced without sooner or later involving the destruction of the host. I am satisfied that it was the enfeebled condition of one monster sun-fish that led to its easy capture by the fishermen of the Firth of Forth. Parasites are constantly present in the sun-fish. I have just received a letter from Dr. Van Dyck, of Beyrout, stating that he also has encountered the *Tetrarhynchus reptans* in this oceanic monster. I am aware that it was lately announced in the pages of *Land and Water* that a recently captured

sun-fish, when dissected, displayed no signs of parasitism. Over and over again it has been my lot to point to evidences of extensive parasitism in animals where others had previously denied its existence, and even in cases where skilful anatomists have been engaged in dissections, I have witnessed such oversights. These so-called "negative results," as they supposed them to be, arose partly from a want of familiarity with the various helminthic types, but more particularly from the circumstance that the various organs of the body of the affected hosts were not exhaustively dealt with. In this matter I attach no blame to any one; for, had I not by long study and by strange experiences been brought face to face with the evidences of diseased conditions resulting from the action of parasites in all classes of vertebrated life, I should have remained to this day as sceptical on this subject as others necessarily are. Fifty years hence the truth of views that are now commonly rejected will perhaps be accepted not only by professional persons, but also by scientists and by cultured persons generally.

DISCUSSION.

Dr. DAY said the meeting must not separate without a vote of thanks to Dr. Cobbold for his exceedingly interesting paper. They knew that amongst the helminthologists of Europe, nobody held a higher position, and that for many years he had been at work on these little animals. It was exceedingly important to know that Dr. Cobbold was as good a practitioner in destroying these parasites as he was in finding them.

Professor Brown Goode seconded the motion, which was carried unanimously.

A vote of thanks to the Chairman, moved by Lord Arthur Russell, and seconded by Mr. John Tremaine, concluded the proceedings.

THE

FOOD OF FISHES

BY

FRANCIS DAY, F.L.S., F.Z.S.,

DEPUTY SURGEON-GENERAL, AND COMMISSIONER FOR INDIA TO THE INTERNATIONAL FISHERIES EXHIBITION.

CONTENTS.

CONFERENCE ON THURSDAY, JULY 12, 1883.

Prof. HUXLEY, P.R.S., in the Chair.

THE FOOD OF FISHES.

IN compliance with a request from the Committee to communicate a Paper on the Food of Fishes to the Fisheries Conference, I have thrown together a few notes upon this vast and interesting but complicated subject. For when one commences to investigate this question, it is found to branch off into many directions, and the inquirer has to consider the locality where the fish reside, whether marine, estuary, or in the fresh waters, as well as the description of the food on which it exists. And as researches are pushed further, it is found necessary to institute an exhaustive inquiry, not only into the nutriment made use of by each of these various classes of fishes, but likewise into what is necessary for the young in their different stages of growth, and in the same fish as it attains maturity.

When the description of food most suitable to each kind has been discovered, it becomes desirable to ascertain what influences there are which tend towards the development of this food or else injuriously affect either its abundance, growth, or distribution. Some valuable forms of fish depend for their subsistence on food which may be

found liable to injury or destruction, and it would manifestly be undesirable to cultivate such, if other species, equally suitable, and which subsist upon food which is practically inexhaustible in amount are obtainable. And this leads us to the conclusion that augmenting the number of fish, unless their food is proportionally increased, or it was originally in excess of demand, would be an error; for neither growth nor health could be present if the fish were being practically starved. Unless we have ascertained what nutriment is essential to the various forms of our sea-fishes, it would seem that we are scarcely in a position to understand their migrations or to legislate upon their requirements.

When we examine into who there have been in Great Britain and Ireland that have investigated the question of the food of fishes, we find but few original observers. Among these I would especially mention Knox, Goodsir, W. Thompson, McIntosh, Dunn of M'evagissey, and Sim of Aberdeen. But however interesting and instructive isolated facts may be, and of these we have many, our fisheries require exhaustive investigations, such as have been carried out in the United States and some of the kingdoms of Europe. Among the last words penned by my old friend and fellow-student Frank Buckland I find the following: "We know, moreover, as yet but very little of the food of these" (sea) "fishes, of what it consists, how, when and where grown, obtained," &c.

For the purpose of efficiently carrying out this much-needed inquiry the investigator ought, in the case of marine fishes, to be, if possible, present when the fish is captured noting the distance from the shore, the depth of the water, the temperature, and the nature of the ground over which he is sailing. And after the species has been secured, it ought to be correctly determined, and the stomach with its

contents at once placed in spirit or other suitable preservative for further microscopic investigation, as, in many species, decomposition sets in with great rapidity, and all trace of the more delicate food becomes rapidly destroyed.

Having ascertained what minute forms or other descriptions of life are employed for the nourishment of the fish, the inquiry branches off into what it is that governs and controls migration of these forms, as currents, soils, temperature, atmospheric vicissitudes, or some more minute food upon which they themselves subsist; what are their enemies and their friends, and the conditions which favour the presence or absence of either class?

Fishes may for convenience' sake be divided into predacious, omnivorous, and herbivorous species, which necessitate an organisation suitable for each. Some are rapid swimmers in order to overtake prey, or escape from their foes; others, which obtain their food by means of stratagem, are constructed for a slower mode of progression. But, for two reasons, I must omit the consideration of form; first, because such are familiar to my hearers, and have representatives among the collections shown in this Exhibition; and secondly, because such would unduly lengthen my paper. The various descriptions of teeth in fishes are more or less demonstrative of the great difference which must exist as to the food they consume: some being prehensile, in order to assist in capturing and retaining their prey; others are more rounded for the purpose of crushing the shells upon which they mainly subsist. In carp the teeth are restricted to the throat, but the variations are too numerous to enter upon in this place.

The commencement of the alimentary canal, or the mouth, is the common receptacle of water passing to the gills for respiration and food transmitted to the stomach for nutri-

tion, while, as might be anticipated, its capacity is large and variously formed. But the several purposes to which the mouth is employed, and the means by which such are effected, it is not my purpose to enter upon at present, except to remark on the absence of the salivary glands, which, in some forms, seem to be represented by mucous follicles that open into the mouth below the side of the tongue. Also that among the carp-like fish the palate is very sensitive, exceedingly vascular, while from numerous small pores mucus of a solvent character exudes, apparently to assist the digestion of food which the pharyngeal teeth are masticating. The gastric portion consists of an œsophagus and a stomach, between which a cardiac constriction is not so frequently observable as a change in the structure of lining mucous membrane. In some fishes there hardly exists any definite line of demarcation between the lower end of the stomach and the commencement of the small intestines, but in many a constriction occurs to this situation, termed the pylorus, which subsequently I shall have to refer to. Occasionally the stomach is situated not in the direct course, but to one side, as it were, of the intestinal canal. A second constriction, marked internally, by a more or less well-defined internal valve, shows where the small intestines terminate and the large ones begin.

If the intestinal canal is slit up and its inner surface examined, the commencement of the stomach is generally observed to be defined by increased vascularity and a more delicate lining membrane than that existing in the œsophagus. Its upper or cardiac orifice is usually larger than its lower or pyloric one, while the form of the entire organ is subject to considerable modification, being usually found in one of the two following divisions: the *siphonal*, which

somewhat resembles a bent tube, as seen in the lump-sucker, flounder, salmon, carp, sturgeon, and most of the plagiostomes; and the *cæcal*, in which it ends in a blind sac, and the pyloric portion is continued from its right side, as observed in the perch, gurnard, weevers, John Dory, whiting, &c. An intermediate or transitional form sometimes exists, as in the sea-scorpion or the turbot, irrespective of which certain deviations occur which it is not my purpose to enlarge upon. The Indian *Sciæna*, erroneously termed whiting (*Johnius*), has the pyloric portion of its stomach muscular, but this augmented thickness of the muscular coats may be best perceived in the mullets (*Mugil*), in which the cardiac portion is continued downwards into a blind sac, while the pyloric portion is thickened like the gizzard of a bird, appearing as a rounded or conical projection externally, and which when cut into is found to consist of thick muscular walls, the small cavity remaining internally being lined with a thick and horny epithelium. This gizzard-like stomach is evidently employed for grinding up hard food, and it is curious to observe how, when some freshwater forms select hard substances for their diet, the coats of their stomachs may likewise become thickened. Thus in the gillaroo trout we find the ascending or pyloric portion of the stomach thickened, due to their existing upon shell molluscs in some of our fresh waters, but which thickening is lost when they become transferred to other localities, as may be seen in a specimen on the table, which died last month in our Aquarium, and which was reared by Mr. Capel from eggs procured in Ireland from the true gillaroo.

Through the pyloric orifice, partially-digested food reaches the commencement of the small intestines, and as a rule we observe that the distance from the pylorus to the vent is

shorter in fishes than in most of the higher vertebrata. But the length of the intestinal tract differs in various classes, while its lining membrane is by no means of the same description in all. In the salmon or herring we find the length of the intestines shorter than that of the body, but in the former the intestinal lining membrane is raised into transverse folds, thus increasing the extent of their secreting surface, which is also further augmented by the presence of numerous cæcal appendages, which I shall have presently to allude to. In the herring, again, the cæcal appendages are numerous. In other forms we find the intestines themselves convoluted, thus increasing their length, and this is well seen among the carps, especially in such as are herbivorous. In the salmon the folds of the internal lining of the intestines increase in size, decrease in number, and become less oblique as they approach the rectum, and, as observed by Owen, the commencement of the large intestine is marked by a large transverse fold or circular valve, which is succeeded by several others less produced, and resembling the *Valvulæ conniventes* in the human jejunum. This large intestine may be straight, as seen in the sturgeon or chimæra, &c., where the transverse folds (as observed existing in the salmon) become continuous, and there is formed an uninterrupted spiral valve, also present in the sharks, the rays, and their allies, but which may be modified into transverse coils.

It is thus that in fishes economy of space is effected by an increase of the secreting and absorbing surface of the vasculo-mucous membrane lining the intestinal tract, whether such be merely raised into puckers, or these puckers be continued into transverse folds, or even forming a circular uninterrupted spiral valve or coil to the large intestine.

An examination into the cæcal appendages, also termed pyloric cæca, and pyloric appendages—what forms possess, and what are deficient in them—under what circumstances they vary—and, lastly, what are their functions? have always appeared to me to be questions respecting which much still remains to be ascertained. One constantly sees observations respecting these organs and their importance, but one rarely finds remarks as to what *rôle* they subserve in the economy of fishes. One author divides species by the number of appendages they possess. Another tells us that they may be considered as lateral prolongations of the intestines, into which food does not enter, and the secretion which comes from them is similar to that of the intestinal mucous membrane. Some consider these appendages to be a modified pancreas, while a very rudimentary form of this organ has been detected as a minute glandular body, terminating in a duct, which opens by from one to three orifices into the intestines, close to the bile duct, but occasionally so closely attached to the latter as to be easily overlooked. It is seen both in fishes which possess pyloric appendages, as perch, cod, salmon, sturgeon, and also in such as are deficient in them, as brama, gar-pike, pike; while the sharks and rays are furnished with a reddish-yellow and lobulated gland, which is more similar to what is perceived in the higher forms of vertebrate animals. In short, we may find both a true pancreatic gland and cæcal appendages existing in the same fish.

What are the common appearances of cæcal appendages? If we commence our investigations among the osseous fishes, we see in some one or more small ducts, each ending externally in a blind extremity; these either surround the commencement of the intestine just beyond the pyloric or lower end of the stomach, or else spring from one of the sides

of the first part of the small intestine, along which they may be continued for some little distance. We find in a single fish from one to upwards of a hundred of these cæcal appendages, each of which may open by a separate orifice into the intestinal canal, or two or more conjoining form a common duct, and thus diminish the number of openings. In the sword-fish (*Xiphias*), all the various appendages conjoin with the common tubes which empty their contents into the intestines. Passing from the osseous upwards to the cartilaginous, or semi-cartilaginous fishes of the ganoid sub-class, we still find this gland present. Thus in the sturgeon (*Acipenser*), a mass of areolar tissue binds the various cæca together, forming it into a parenchymatous conglomerate gland.

Food, climate, and increased space of water, or all combined, exercise a modifying influence upon the cæcal appendages of fish; thus trout in Tasmania, reared from eggs sent from Hampshire and Buckinghamshire, have increased largely in size in their new home, augmented the number of their cæcal appendages, and are now in most respects identical in appearance with the *Salmo ferox* of our larger lakes.

Respecting our freshwater fishes, their food has been more closely investigated than has that of our marine forms, and, for very obvious reasons, the owner of a fishery, if he takes any interest in its development and success, watches whether his fishes thrive or deteriorate, and also endeavours to ascertain to what cause such may be due. Possibly his fish-ponds may be too full of small and inferior kinds, which, by devouring the food, leave but an insufficient supply to the more valuable table sorts. Possibly the food itself is deficient in quantity or nourishment. But all these questions fall so naturally to the freshwater fisheries,

which have been so elaborately brought before this Conference, while that of salmonidæ will doubtless be fully discussed by Her Majesty's assistant inspector of salmon fisheries, whose Paper immediately succeeds the one I have the honour to read before you, that I have purposely omitted reference to freshwater and anadromous species, confining my remarks as much as possible to marine forms. and those most suitable as food for man.

If only by the knowledge of what is required, combined with care and attention in carrying such out, can the management of private ponds be made successful by the fish culturist; if leaving them to chance, and withdrawing control, eventuates as completely in their ruin as it would to leave arable lands to be self-sown, such only leads us to consider whether, in time, the same want of judicious management might not have equally disastrous results upon the fisheries of lakes and rivers, although possibly at a longer interval of time. Probably among the attractions which entice inshore some of the more predaceous marine forms, are fish which have descended rivers to the sea, where they linger about the estuaries.

Respecting feeding, many forms nearly or entirely omit doing so at breeding periods, as the salmon, trout, and anadromous shad, while the herring, more or less, ceases at these times. On the other hand, pike and barbel will take food at those times. During the cold season a cessation of feeding occurs among many forms of fish. In the East it is curious to observe some of the sheat-fish, or siluroid family, wherein the male carries about the eggs in his mouth until they are hatched (examples of which are in the Indian collection in the Exhibition). If he fed at these times, the eggs would certainly be swallowed, but he does not do so, as I have

convinced myself by opening many specimens, in all of which the intestines were destitute of food.

When a fish is first hatched, we see a large sac depending from its lower surface, this being the yelk or umbilical sac, in which nourishment is contained, and sustains the young for a longer or shorter period. After this food has been absorbed, the fish culturist frequently finds great difficulty in procuring suitable nourishment for his young charges.

Fishes are to a great degree highly voracious; thus, Dr. Houston showed in 1847 at the Zoological Society the skeleton of an angler *Lophius piscatorius* two and a half feet long. Inside its stomach was the skeleton of a two-feet long cod fish, *Gadus morhua*, within whose stomach again were contained the skeletons of two whiting, *Gadus merlangus*, of the ordinary size, while inside the stomach of each of these fish lay numerous half-digested bones of little fishes, which, however, were too small and too comminuted for it to be possible to identify the species they belonged to.

In warm-blooded animals a large amount of food is necessary in order to produce the high temperature of the blood, and make up for the wear of the body produced by constant motion. But in cold-blooded forms a different condition exists, in them nutriment being mostly employed for increasing the size of the animal, a much less amount of food being required to sustain the smaller wear and tear resulting from the little motion which is often perceived, especially in fresh-water forms.

In most of the shallow portions of the sea around our coast are distributed various descriptions of sea weeds. Should the bottom be rocky we find brown algæ (*Fuci*), while further out from the tide line are red algæ (*Floridi*).

But with increasing depth we observe less vegetation, or should algæ drift to sea they subside to the bottom, constituting that soft black mud seen in some of our bays, in which worms, molluscs, crustaceans, and other marine animals have their home, and find subsistence, while they in their turn become food for fishes which rout out and consume them. Professor Mobius, at ninety to ninety-five fathoms in the Baltic, where the bottom is formed of plastic clay, found very few worms. In the Mediterranean, at the south-east of Sicily, where the bottom consists of yellowish clay, the British exploring expedition detected no trace of animal life. But in the southern portions of the North Sea, at from twenty to twenty-five fathoms, and with a muddy bottom, such is found to be alive with worms, small crustacea, snails, molluscs, echinoderms, and fish, and, as a result, with fish which prey upon them. Irrespective of the foregoing algæ found in the ocean, there may be microscopic forms so abundant as to render the surface almost turbid. Diatoms live in every sea, their remains forming the principal portion of the finer particles at the bottom, they are swallowed by Pelagic animals, as salpæ, pteropods, &c., which after death subside in the waters. Likewise all rivers carry organic matter into the ocean, rendering the bottom rich in food, and a resort for invertebrate animals, and consequently fish which prey upon them. Currents which carry plants and small marine creatures from place to place, must likewise influence, through food, the migration of fish, for the temperature, salinity, and currents of the sea exercise a great influence upon animal and vegetable life.

Although the growth of fishes much depends upon the suitability and abundance of the food which they are able to obtain, other causes likewise play an important part. In some forms, as the turbot, it would appear as if they aug-

ment more rapidly in an aquarium when supplied with suitable nourishment than they do in the open sea. Thus in the Southport aquarium some about three inches across, increased in two and a half years to 10 lb. in weight, and after two years more they further augmented to 20 lb., or a yearly average in amount of 4½ lb. a fish.

In marine fisheries the question of the food upon which the various forms of fish subsist is of vital importance, as on it greatly depends whether legislation might be reasonably expected to prove useful, superfluous, or mischievous. Many forms are omnivorous, others carnivorous, and a few herbivorous. Some, like the sucking fish *Remora*, attach themselves to the bodies of whales, sharks, and larger fishes and so are carried about by their host, upon whom they do not prey, but simply use him as a means of conveyance, and these are termed commensals. Others, as the borer or hag, *Myxine glutinosa*, is a true parasite, attaching itself to another fish, into which it bores and devours, subsequently passing on to fresh victims. Some fishes, as the pilot fish, *Naucrates ductor*, or the black fish *Centrolophus pompilus*, would seem to keep company with whales, sharks, sun fishes, and other forms, mostly for the purpose of subsisting upon the parasites which infest these larger species, or to obtain their excrementitious dejections. The lamprey, besides attacking living fish, likewise prey upon such as are in an advanced stage of putrefaction, and many forms will not only devour the eggs and young of their neighbours, but likewise those of their own species. In a sturgeon's stomach Thompson observed several examples of minute crustaceans (*Amphipoda*), the remains of shrimp-like forms, fragments of *Porphyra*, which had probably been growing on the sandy bottom of the sea, and a perfect, but minute *Tellina tenuis*; it likewise contained some fine sand, with which the intestines were wholly filled. The *Polyodon*

folium of the Mississippi is supposed by fishermen to feed upon the mud and slime at the bottom of the river, but is found to consume an enormous amount of entomostraca, while fully one-fourth of its food is composed of vegetable algæ, which are obtained by means of its long and double row of fine gilt rakers, forming a strainer, which permits the passage of the fine silt of the river, but arrests everything else as large as a cyclops. In the New South Wales section of this Exhibition may be seen the teeth in the jaws of a shark, *Heterodontus galeatus*, stained of a pinkish purple, due to its feeding largely on an Echinoderm common in Port Jackson, the *Centrostephanos rodgersii*, which stains them of that colour. This tempting morsel has spines about three inches long, and must be a very prickly subject to swallow. The spines of other Echinoderms, *Amplypneustes ovem* and *Strongylocentrotus erytherogrammus* have also been found in the intestinal tract of this fish. The torpedo, or cramp fish, paralyses its victim.

The colours of fish may be dependent upon the food on which they subsist; thus Professor Mobius found in the stomach of some cod large pieces of two marine plants, *Ulva lactaca* and *Zostera marina*, irrespective of shells, snails, crabs, and fishes. These had affected the external colour of the cod, and thus became indicative of the depths at which they live; these variations comprised white, yellowish brown, speckled, green, and black. The same change of colour, induced by alterations in food, has been observed at Sir James Gibson Maitland's trout ponds at Howietown, near Stirling.

Some fishes feed at night-time, others during the day; while what is eaten when in captivity is not invariably a criterion of what they consume when in a state of nature. Thus in Ireland cod fish and haddock kept in vivaria have

been said to prefer boiled potatoes to every other description of food.

For the purpose of illustrating upon what marine fishes subsist, I have deemed it advisable to select classes which are most useful to man. The sea fisheries for practical investigations may have their finny inhabitants (as already remarked) divided into: (1) such as generally reside in or near the surface of the sea; (2) such as swim in moderate depths or at the bottom, and (3) lastly, those which are ground feeders. It is evident that unless the food which all subsist upon is identical, and that such is found at all the various depths which these different fishes inhabit, what causes would be injurious to the food partaken by one class may be perfectly innocuous to that which the other classes live upon. The whelk, *Buccinum*, and the mussel, *Mytilus*, at the bottom may be consumed by bottom feeders, but they would not afford sustenance to herrings which mostly frequent the upper strata of our seas, where they prey upon small crustacea and other forms of food. The ground feeder, as the sole, turbot, or brill live on what is normally present at places they frequent; anything which tends to injure the various kinds of animal life found at these places must tend to destroy what would be food for fishes.

The heads for a brief investigation may be divided into what is the food of the more gregarious kinds of fish, as of the mackerel, herring, or pilchard, forms which when investigating the subject of their food ought to be kept essentially distinct from the more sedentary and local residents. And in tracing this question of food it will be best to proceed from the more predaceous to the more preyed upon fishes. Sharks and their allies follow shoals of the herring family, as I had the opportunity of investigating off the western

coast of India, where on the disappearance for several successive seasons of the oil sardine, sharks, saw fishes and skates were absent, while all these forms returned simultaneously. We see also on our coasts the strong follows the weak, and preys upon him if a sufficiently dainty morsel.

The mackerel, it has been observed, swim higher or lower in the water in accordance with atmospheric vicissitudes, most probably due to the influence of such upon the food they subsist upon. Thanks to Mr. Dunn, of Mevagissey, I have had the opportunity of investigating the food consumed by the mackerel at various seasons of the year, when I was not able to be on the coast: in the summer and autumn they follow the herring and take heavy toll, especially during the later months of the year, upon the britt, which are the fry of those fishes and of the sprat. About the middle of May along the south coast they are especially partial to the mackerel midge, which is the young of rockling (*Motella*). They also prey upon small crustacean forms. In March, 1882, the contents of the stomach of some of these fishes, sent me from Mevagissey and which had been captured eight miles from land in over forty fathoms of water, consisted of small crustaceans *Thysanopoda Couchii*, which form was originally procured by Couch in a similar manner. In May, 1880, I opened a number from the south-west coast, all were gorged with ova. In May, 1883, Mr. Dunn found Mevagissey Bay swarming with entomostraca, and similar animals were present in the stomachs of the mackerel and pilchards. These copepods consisted of *Centropages typicus*, Kröyer; *Temora longicaudata*, Lubbock; *Calanus Finmarchicus*, Gunner (A. Norman). Mackerel consume other fish, following the herring and their young, the fry of the rockling, various forms of crustacea, also of ova, and in fact prey upon a large amount

of animal food, while it again is pursued by the tunny, the sharks, dog-fishes, and other forms stronger than itself.

The herring, so valuable to the fishermen of these islands, is another gregarious form, appearing and disappearing from some places in a way often inexplicable to the fishermen. If, however, an investigation were made, it is probable that their seemingly eccentric movements may be caused by the appearance or diminution of some peculiarly acceptable description of food on which they subsist: this is generally held to consist of minute shrimp-like crustacea, often of forms belonging to the same division as the common *Cyclops* of our fresh waters. But it is also evident that it feeds upon very varied forms of animal life, and probably is not particular what it is, providing it can obtain sufficient. In February, 1882, I found that some sent me by Mr. Dunn, from Mevagissey, had been feeding upon annelids: from the same locality in the middle of May their stomachs were crammed with sand-launces (*Ammodytes*), some of which were up to 2½ inches in length, and as many as nineteen were inside one herring, while the sand-launces in their turn were full of the remains of crustacea. A month later from the same place and captured about eight miles off shore, the food had again changed and consisted almost entirely of the young of a very rare gobioid fish (*Crystallogobius Nilssonii*), the largest of which was 1⅓ inches long, there were also a few young herrings and sand-launces. At the end of May, 1883, herrings were again found to be gorged with the young of the *C. Nilssonii*, a remarkable fact, as only one adult specimen of this Scandinavian species has been recorded from the shores of the British Isles, and that was obtained by Mr. Edward, of Banff. From whence then do the herrings follow these little gobies?

Knox obtained from the stomachs of some herrings from

the deep-sea, sand-eels from one, what appeared to be young herrings from another, and other small fish. Goodsir, (*Edinburgh New Philosophical Journal*, July 1843), gave the result of his examination of the *maidre* or food of the herring in the Firth of Forth, with which the stomachs of the fish were found to be filled. Cirripods, Crustaceans, and Acalephæ were detected, of which crustaceans were in the largest number, and consisted of masses of *Amphipoda* and *Entomostraca*. Among the Acalepha the different species of *Beroæ* were seen in the greatest numbers. While he wrote from Austruther, in 1843, that the herrings follow the shoals of Entomostraca to prey upon them, for it is only when the latter make their appearance on this coast that the former are seen, and when the food is most plentiful the herrings are in the best condition.

Off Lofoten Sars found the sea swarming with microscopic animals, especially small crustaceans termed "herring food." They were mostly *Calanidæ* and chiefly *Calanus Finmarchicus* and *Temora longicornis*. This herring food depends for its existence on lower and smaller organisms as diatoms, while the slime of Christiania Fiord chiefly consists of such, and it also largely composes the slime of the polar seas.

H. Widegren, of Scandinavia, observes that the food of the young, as well as of the grown herring, consists chiefly of small crustaceous animals, invisible to the naked eye, which are found in enormous quantities in the sea, both in shallow and deep water, and may be detected by straining water through a cloth. "Their quantity varies at different seasons, during a change of temperature and at different depths, and this probably is the reason why these fishes are taken at different depths, in accordance with temperature or currents."

Mr. G. Sim, of Aberdeen (Edinburgh Prize Essays Fish Exhibition, 1882), found in the stomachs of those he examined, the young of their own kind, also of sprats. Of stalk-eyed crustacea, examples of *Galathea*, *Mysis*, *Thysanoessa*, *Thysanopoda* and *Acanthocaris*, several larval forms of *Brachyurus*, some of which were very abundant. Of sessile-eyed crustacea, *Hyperia*, *Lestrigonus*, and one species of *Æga*. Of Entomostraca, *Cythere*, *Temora*, and *Evadne*. Of the foregoing, *Hyperia* and a young univalve mollusca, *Sagitta bipunctata* (?), *Mysis spiritus*, and young herrings and sprats formed the largest portion of their food, the last two being most abundant from December until May. From May until October, *Temora longicornis* is their most common food, and from December till February, *Hyperia galba* and *Sagitta bipunctata*. The other forms of animal life, it appeared to him, might be classed as a sort of chance food, while, although two species of sessile-eyed crustacea, *Amathilla Sabini* and *Atylus Swammerdamii*, swarmed along the coast, he never found either in the stomach of the herring. Mr. Sim points out how similar in external appearance is the *Hyperia galba* on which it feeds, to *Atylus Swammerdamii*, which it rejects, and suggests whether taste or smell may not exercise an influence.

The food of the herring varies in accordance with what most desirable form exists at the locality which it frequents, and it devotes its attention to the young of fishes, or of its own kind, or of the sprat; the young of the sand launce, and likewise of a small gobioid along our southern coast. Stalk-eyed, sessile-eyed crustacea, and entomostraca, afford it nourishment, and Acalepha have also been detected in its stomach. As it appears to exercise selection in the forms it devours as food, it is probable that it would follow such to wherever they migrate, as along our

coast, or into our bays, unless their progress were checked by any extraneous causes.

Passing on next to consideration of the fishes which we possess, belonging to the cod family, what are the chief characteristics of their food? They may be found of surface and littoral forms, and along our coasts at depths rarely exceeding 120 or 150 fathoms, while the common cod, *Gadus morrhua*, is noted for its omnivorous appetite. The cod will consume small fish, or the young of its own kind, or of any other that they can capture; but seem to be especially partial to sand-eels, herrings (which they will tear out of the nets), and their spawn, and sprats: while Leach found six dog-fishes inside one of these fish. Crustaceous and testaceous animals also, as is well known to fishermen, evidently prefer one kind of animal food to another, being very partial to crabs and whelks, while their digestion is so powerful that the greater portion of the shells they swallow are dissolved. Various, indeed, have been the contents of the stomach of these fishes; an entire partridge has been taken from one, a hare from another, and a black guillemot from a third; while from two others have been removed a piece of tallow candle, and a white turnip, irrespective of a bunch of keys; stones are frequently found inside these fish, having been probably swallowed in order to obtain the corallines which were attached to them, the stones being subsequently ejected. They will eat almost any kind of crab, indeed, almost any kind of animal food. Dr. M'Intosh obtained the following food from cod-fishes captured at St. Andrews.

A zoophyte, *Thelepus Lima Loscombii*, G. B. Sowerby; *Mediolaria nigra*, Gray; *Crenella decussata*, Mont.; *Nucula nucleus*, Linn.; *N. nitida*, G. B. Sowerby; *Circe minima*, Mont.; *Scrobicularia prismatica*, Mont.; *S. alba*, Müller;

Solen pellucidus, Pennant; *Chiton cinereus*, Linn.; *Trochus tumidus*, Mont.; *Turritella terebra*, Linn., a favourite food probably in many cases on account of its tenant, the hermit crab; *Trichotropis borealis*, Brod. and Sowerby (1 ex.); *Trophon truncatus*, Ström.; *Pleurotoma Trevelyana*, Turton; *Philine scabra*, Müller; *Tritonia Hombergi*, Cuv. (occasional); *Loligo vulgaris*, Lamarck; *Eledone cirrosa*, Lamarck; *Amphiura Chiajii*, Forbes; *Ophiopholis aculeata*, O. F. Müll.; *Echinoscyamus angulosus*, Leach; *Cucumaria Hyndmanni*, Thomp.; *Thyone fusus*, O. J. Müll.; *Thyonidium Dubeni*, Norman; *T. commune*, Forbes and Goodm. (1 ex.); *Priapulus caudatus*, Lam.; *Aphrodita aculeata*, Linn.; *Lepidonotus squamatus*, Linn.; *Enipo Kinbergi*, Mgrn. (occasional); *Sthenelais limicola*, Ehlers; *Sigalion Mathildæ*, M. Ed.; *Nephthys cæca*, Fab.; *N. Hombergii*, And. and M. Ed.; *N. Johnstonii*, M'Int.; *Phyllodoce grœnlandica*, Ærst.; *P. laminosa*, Sav.; *Alitta virens*, Sars.; *Lumbriconereis Lamentiana*, Grube; *Goniada maculata*, Ærst.; *Glycera capitata*, Ærst.; *G. Goësii*, Mgrn.; *Ophelia limacina*, H. Bath; *Terebellides Strœmii*, Sars; *Sabella pavonia*, Sav. Among crustacea, *Hyale Nilssoni*, H. Rath; *Anonyx Holböllii*, Kröy; *Ampelisca carinata*, Bruz.; *A. Belliana*, Bate; *Dexamine spinosa*, Mont.; *Atylus Swammerdamii*, M. Ed.; *Gammarus marinus*, Leach; *G. locusta*, Linn.; *Caprella tuberculata*, Guérin; *Eurydice pulchra*, Leach; *Arcturus longicornis*, Sow.; *Idotea tricuspidata*, Desm.; *Diastylis Rathkii*, Kröy; *Palæmon squilla*, Linn.; *Pandalus annulicornis*, Leach; *Nephrops Norvegicus*, Linn.; *Gebia deltura*, Leach; *Galathea strigosa*, Linn.; *G. squamifera*, Mont.; *G. dispersa*, Bate; *Ebralia tuberosa*, Penn.; *Hyas araneus*, Linn.; *H. coarctatus*, Linn.; *Portunus depurator*, Linn.; *P. holsatus*, Fab.; *Atelecyclus septemdentatus*, Mont.

Haddocks likewise feed near the ground, and, for their

size, are as voracious as the cod; their food varies in accordance with the locality inhabited. They consume herrings, sprats, and other small fish during the warmer portion of the year, and in the winter are found to swallow stone-coated worms, *Serpulæ*, which the fishermen term haddock meat; while they will also consume shell-fish and take bait similar to those used for the cod. Dr. McIntosh obtained the following from examples of this fish captured at St. Andrews:—*Pecten tigrinus*, O. F. Müller; *P. similis*, Laskey; *Creuella decussata*, Mont.; *Nucula nucleus*, Linn.; *N. nitida*, G. B. Sowerby; *Circe minima*, Mont.; *Tellina pusilla*, Phillipi; *Scrobicularia prismatica*, Mont.; *S. alba*, Müller; *Solen pellucidus*, Pennant; *Chiton cinereus*, Pennant; *Trochus tumidus*, Mont.; *Trophon truncatus*, Ström.; *Pleurotoma Trevelyana*, Turton; *Philine scabra*, Müller; *Eledone cirrosa*, Lamarck; *Amphiura filiformis*, A. O. Müller (rare); *A. Chiajii*, Forbes; *Ophiura albida*, Forbes; *Echinoscyamus angulosus*, Leach; *Cucumaria Hyndmanni*, Thomp.; *Thyone fusus*, O. F. Müll.; *Thyonidium Dubeni*, Norman; *Priapulus caudatus*, Lam.; *Aphrodita aculeata*, Linn.; *Lepidonotus squamatus*, Linn.; *Enipo Kinbergi*, Mgrn. (occasional); *Travisia Forbesii*, Johnst.; *Scalibregma inflata*, Ball; *Sthenelais limicola*, Ehlers; *Sigalion Mathildæ*, M. Ed.; *Nephthys cæca*, Fabr.; *N. Hombergii*, And. and M. Ed.; *N. Johnstoni*, M'Intosh; *Phyllodoce grœnlandica*, Ærst.; *P. laminosa*, Sav.; *Lumbriconereis fragilis*, O. E. Müll.; *L. Lamentiana*, Grube; *Onuplus tubicola*, O. F. Müll.; *Goniada maculata*, Ærst.; *Glycera capitata*, Ærst.; *G. Goësii*, Mgrn.; *Ammotrypane aulogaster*, H. Rathke (occasional); *Ophelia limacina*, H. Rath.; *Eumenia crassa*, Ærst.; *Chœlopterus Norvegicus*, Sars; *Maldane biceps*, Sars; *Terebellides Strœmii*, Sars. Among crustacea, *Lysianassa atlantica*, M. Edw.; *Anonyx*

Holböllii, Kröy.; *Callisoma crenata*, Batc; *Ampelisca carinata*, Bruz.; *A. Belliana*, Bate; *Amathilla Sabini*, Leach; *Gammarus locusta*, Linn.; *Caprella tuberculata*, Guérin; *Cirolana spinipes*, M. Ed.; *Eurydice pulchra*, Leach; *Arcturus longicornis*, Sow.; *A. gracilis*, H. Goods.; *Idotea tricuspidata*, Desm.; *Diastylis Rathkii*, Kröyer; *Paudalus annulicornis*, Leach; *Hippolyte varians*, Leach; *H. spinus*, Sow.; *Gebia deltura*, Leach; *Galathea strigosa*, Linn.; *G. dispersa*, Bate; *Pagurus lævis*, Thomp.; *Ebralia Cranchii*, Leach; *Hyas coarctatus*, Leach; *Portunus holsatus*, Fab.; *P. pusillus*, Leach.

These are forms in which the destruction of shell fish and crustacea means the deprivation to the cod family of a portion at least of their food; and, unless that food had previously been largely in excess, much destruction must eventuate in either a decrease in the quantity of nourishment for each individual fish, which would probably cause them to become inferior in quality; or else it would have to be met by a decrease in the number of fish residing in a given space of water.

The last class I shall refer to are ground fish, *Pleuronectidæ*, as halibut, turbot, brill, soles, plaice, and other marine kinds, the food of which varies widely from that which is consumed by the gregarious surface swimmers, or the more omnivorous midwater forms. Destitute of an air-bladder, and generally with mouths comparatively smaller than exists in the more predaceous members of the cod family, we find them essentially ground feeders. Their diet consists of almost any invertebrate form, by them shell-fish and crustacea are largely consumed, as are also small fish and fish-eggs. Dr. M'Intosh, at St. Andrews, obtained the following varieties of food from flounders captured there:—*Pecten tigrinus*, O. J. Müller; *P. similis*, Laskey;

Circe minima, Mont.; *Tellina pusilla*, Phillipi; *Chiton cinereus*, Pennant; *Trophon truncatus*, Ström; *Philine scabra*, Müller, and *P. pruinosa*, Clarke (rare); *Sepiola Rondeletii*, Leach (1 ex.); *Echinoscyamus angulosus*, Leach; *Sthenelais limicola*, Ehlers; *Lumbriconereis fragilis*, O. Müll.; *Glycera Goesii*, Mgrn. Among crustacea, *Hyale Nilssoni*, H. Rath.; *Ampelisca Belliana*, Bate; *Arcturus longicornis*, Sow.; *Idotea tricuspidata*, Desm.; *Diastylis Rathkii*, Kröyer; *Hippolyte securifrons*, Norm.; *Galathea dispersa*, Bate; *Hyas coarctatus*, Leach; *Portunus pusillus*, Leach.

Around our coast, whether correctly asserted or not so, still fishermen appear to believe that our inshore fisheries are being depleted, and only last week the following remarks in the *Field* appeared from the pen of Mr. Barber, of Mevagissey:—"Long-line fishing all along our coasts is now in the ascendant, and the system of fishing with hand-lines is gradually becoming obsolete; but although a larger amount of fish is being caught than under the old system, it is evidently a most destructive method, as a great many fish which get hooked, in the death-agony twist themselves off the line with the hooks attached, and must evidently waste and die to no purpose. We believe the time is fast approaching when this system of fishing will exterminate all the conger-eels, cod, ling, ray, and skate within twenty miles of our coast, as now, to be successful, the boats have to proceed at least double that distance from shore, which seems a striking contrast when compared with the heavy hauls which were made some ten years since by hand-lines at a distance varying from five to ten miles off, where now scarcely any fish of the description mentioned are to be caught.".

I must now bring to a conclusion this most imperfect sketch of the food of our fishes, a subject which, were it

fully worked out, would furnish materials for volumes instead of pages. I have been forced to restrict myself to the consideration of a few carnivorous, omnivorous, and vegetable feeders as typical of what takes place in the vast community of the finny tribes. I have attempted to demonstrate that inshore fisheries, as of the haddock and its allies, may be depleted, owing to the destruction of the food on which those fish subsist, and which may have little or no connection with the food which is eaten by gregarious kinds, as the mackerel and herring, which appear at certain seasons off our shores in enormous numbers. It cannot be too strongly impressed upon those who do not personally search for their information in the homes of the fish, that although in some points injuring one set of fisheries may react upon another, still one class may be depopulated while another is but slightly affected. To argue that because large numbers of herring and mackerel are brought to market therefore all our sea fisheries must be in an eminently satisfactory state, is about as conclusive as to suppose that because sea-birds are abundant no protection is necessary for those living on the land.

While I cannot resist holding the belief that not only is the destruction of certain forms of fish food possible by man, I think it is proved that such occurs, thus starving fisheries. The following instance may be adduced to show how their food producers have become impoverished. In some localities the mussel beds have been thrown open without restriction to every comer, and at most of such places this fish food has almost disappeared, in the remainder it is hastening to decay.

I am as averse to legislating upon fisheries without due inquiry being instituted into all their conditions as any one can be, but I cannot help thinking that one of the mem-

bers of this Conference offered us a sound and well-needed warning, when he said he was equally averse to sea fishery laws which had existed for centuries being summarily abolished without, as it appeared to him, a due investigation and exhaustive inquiry having been first made into the true condition of the fisheries, fishermen, and all connected therewith.

Whilst experience would seem to point out that we must either give protection to our fishes, or replace in our waters by artificial means a number sufficient to keep up the supply. We may be doing an injury in our endeavour to effect good, for suppose no soles below a certain size were permitted to be captured, the useless little sole, *Solea minuta*, which rarely exceeds 3½ inches in length, would escape destruction. By preserving it we may be protecting a form which consumes the identical food as its relative the more valuable common sole (*S. vulgaris*), and in this manner permit it to devour what would otherwise form the food of its more valuable relative. In fact, we see the boar fish (*Capros aper*) first recorded as British in 1825, and considered useless as food, has now become so abundant in places as to prove a perfect pest; the trawlers along the south-west coast having been obliged to change their ground in order to get out of their way. Such immense numbers sometimes obtain entrance into the trawl, that holes have to be cut in order to allow them to escape, as it has been found almost impossible to lift such a bulk on deck without carrying away the gear.

One argument adduced against legislating in fisheries hardly coincides with the lessons we learn when investigating the food of the finny tribes. We are told that legislation would be interfering with the "balance of nature," which if left alone would surely eventuate in the "survival of

the fittest." Such an argument cannot hold good respecting fresh-water fisheries in populated districts, where man, unchecked by wholesome restrictions, not only can, but does, ruin fisheries. Can it be advanced that the balance of nature is left unchanged when man commences to fish the sea with the sole desire to obtain all he is able? This cannot be, for in the open waters he kills his millions of mackerel and herring which he requires as food, but he takes little or no notice of the sharks and dog-fishes which prey upon them, and are left to multiply, protection being practically obtained by them due to the little use their bodies are to man. Is not this mode of fishing destroying the balance which I hold exists wherever nature and nature's works are left entirely to nature's laws, unaltered by the advent of predaceous man, but his rapacity at once changes the normal conditions. Many of us must have been struck by the instance adduced a short time since by Sir Lyon Playfair, who, while arguing against regulating fisheries, observed that we cannot alter the balance of nature without causing mischief. He informed us that it was within the sphere of his personal knowledge on the west coast of Scotland, where fishermen for some cause were not plying their occupation, that predaceous fishes were depleting the breeding beds of the herring. Here leaving the balance of nature to itself appears (according to Sir L. Playfair's views) to have resulted in a loss to the fisheries, but he argued that the fishermen should be permitted to catch fishes all the year round. In fact, he obtained, as a result of his observation, a regulation that herrings ought not to be left alone at the breeding season, and consequently they were fished subsequently at this time of the year with the most favourable results. If facts and results were as given, one would have imagined this advent

of man on the scene would have been an interference with nature, but we are on the contrary assured that unaided nature, unable to maintain the requisite balance, had to be assisted by the fisherman, and then, and not until then, all went well.

Gulls and sea-birds which prey upon herrings are protected by law; the young herrings have now no protection, but are being consumed wholesale in our land, and no young are being raised by man's artificial means to replace the destruction caused by man. Our inshore fisheries are being depleted, is the assertion around our coasts; and whether this is due to absence of food or immoderate destruction of immature fish has still to be ascertained by a judicious investigation carried out as in the United States. Without giving any opinion on the cause of this depletion, I would suggest that instead of raising a cry against the price of fish, a more probable road for inquiry would be into the state of our sea fisheries, and whether by any, and, if so by what, restrictions, or by what means, they can be restored to their original abundance, and afford a cheap and wholesome food to the teeming millions of these isles.

DISCUSSION.

Professor BROWN GOODE moved a vote of thanks to Dr. Day for the very interesting and satisfactory paper he had read, which he had no hesitation in saying was the most philosophic and comprehensive treatise on the subject which had yet been prepared. He had referred to the studies which had been made in the United States on the food of fishes, and on the circumstances which surround fish in their natural homes. He might say from the beginning of the organization of the United States Commission, ten years ago, no

subject had commanded more attention than this, because if there were no food there would be no fish, and if the fish which preyed on the useful fishes increased in number sufficiently it was quite evident that man had an evil to contend with in the capture of those useful fishes whom he could not hope to equal in any way. The food of fish was of great importance both to the fishermen and to the fish culturist. The fisherman by his careful observation of the habits of fish was able to pursue them to much better advantage. He had seen a great deal of fishermen for the last ten years, and many of them were natural observers of great ability. They waited the appearance of the schools of swarming crabs and shrimps, and other little fish on which the large fish preyed, and by the study of these animals shaped the course of their vessels and selected their fishing grounds, and not only so, but selected their bait also. A skilful fisherman always tried to give the fish he was trying to catch a bait corresponding to that they were feeding on naturally at the time. At the cod fishery of Labrador the bait used was almost entirely caplin, because at that time the cod would take hardly any other bait. On the coast of Norway the same thing occurred; but when they went on the Grand Banks to fish they used herring because herring was schooling there in great abundance and the cod would not take anything else. In the winter when fishing off the coast of New England they knew the fish were feeding at the bottom and so they used clams, which were consumed by hundreds of thousands of barrels, the herrings being then almost of no use at all. In this particular region where this fishery of clams was carried on there were acres and acres almost square miles at the bottom covered with beds of clam shells; they were packed like little nests of Japanese wooden trays, and

evidently the cod fish had swallowed the clams five and six at the time, digested off the contents, and the shells had been piled up in this way in their stomachs for compactness of stowage and ejected. These clam-shells had been picked up by 100 bushels at the time; but the fishermen also watched the food of the mackerel, and followed them along the coast very largely in advance of their movements. This was principally crustaceæ. They followed the crustaceæ along the coast, not so much by seeing it, because it was too small to be readily seen, but by watching small birds, sea geese as they called them, which fed on these crustaceæ, whenever they noticed them they knew that if they set their bait for mackerel they would be likely to be successful. An interesting point which arose from the observations of fishermen was the relation which different kinds of fish had to each other, and the changes in the distribution of different species depending on this question of food. About twenty years ago mackerel was very abundant in Massachusetts Bay, but suddenly there appeared great shoals of blue fish, fish of, say, 16 to 20 lbs., exceedingly predaceous, which destroyed all other fish in great numbers. That fish which had been absent from the coast for many years made its appearance suddenly round Cape Cod, and before this the mackerel vanished, and the mackerel fishery decreased exceedingly; but at the same time there was a corresponding increase in the lobster fishery. No one knew what to make of it until a very acute old fisherman, Captain Attwood, went to work and studied the subject, and he demonstrated pretty plainly that the absence of the mackerel had had the effect of increasing the number of lobsters, because the mackerel were in the habit of feeding on lobster eggs. The blue fish destroyed the mackerel, and that gave the lobsters a chance to breed. Now the

mackerel had come back in great numbers and the balance was more nearly established. Another thing showing the great importance to fishermen of the food of fish was this, that the Menhaden herring, and certain other fish fed on the larvæ, and young shell-fish, crustaceans, which had the peculiar property of heating, as the fishermen said, in their stomachs after it had been caught, so that it was exceedingly difficult to keep them long enough to cure them. In Salem Harbour, where this heating food was particularly abundant, it was the practice of fishermen to pen up the fish for a short time in the nets in order to allow the food to digest before they attempted to cure them. He believed the same thing was practised by Swedish fishermen in the case of the herring. He had mentioned in the Paper he read a few days ago, the circumstance of the change in the habits of the Menhaden herring on the American coast. This was a fish of the utmost importance, some three thousand or four thousand fishing vessels being employed in this fishery, and perhaps a capital of two and a half million dollars. In 1878, for some inscrutable reason, the Menhaden herring disappeared; he had no doubt it was due to a change of temperature, though it was not quite clearly established, and there was a corresponding decrease in the yield of the fisheries. The fish on the coast of Maine were very fat, owing to the fact that they had great sounds to feed in where they could sink down to the bottom and fill their stomachs with the rich bottom ooze; and the fish taken in that region would yield six gallons of oil to one hundred fish. When the temperature barrier excluded them from the Gulf of Maine the fisheries were carried farther down the coast, but it was found that the amount of oil decreased considerably, and the value of the fisheries fell off propor-

tionately. Now within a few days he had received information from two sources that this fish were coming back to the Gulf of Maine in very large numbers; and the fact that they were coming back where they could get food suitable to yield this large amount of oil would be of great importance to the American fishermen, and would no doubt increase the value of their take to something like a million dollars annually.

Professor HUBRECHT, in seconding the vote of thanks, said the question of the food of fishes was of the greatest importance, and at the same time the investigations required were difficult and complicated. It would be gathered from the Paper that it was not so much from kindly attention towards the fish that their appetites were so much considered, but more in order to increase if possible the number, or at least to keep up as far as possible the stock of those useful to man; so that, after all, this inquiry into their food was of rather a selfish character. This was not a very flattering reflection, but still, on the other hand, they might be consoled by remembering that they had also heard from Dr. Day that fishes not only ate their fellows, but also their relatives and even offspring, and therefore it might be considered that when a few fish were caught for the use of man, it would save a great number of others from destruction.

Dr. SPENCER COBBOLD thought it would be a pity that the audience should disperse without some further remarks on this extremely valuable Paper. It had so many bearings, not only those which had been so well spoken of by Professor Goode, but also others which would not be so apparent to a general audience. It would not escape notice that in this Paper it had been stated that small

crustaceæ—entomostraca and their allies—formed in many cases the principal basis of the food of fish. Now it so happened that it was these small creatures, when swallowed, performed a function quite apart from that of the nutrition of the fish which swallowed them. There was, he took it, not a single marine or fresh-water crustacean of small size which was not liable itself to entertain or harbour parasites, which must occur in innumerable quantities; but it so happened that all the known parasites, of which there were many thousands, which were obtained from the bodies of fish, gained their entrance to the said fish through food, and that this food was, in nine cases out of ten, if not in ninety-nine out of one hundred, small animals. So curious was this subject, that one single statement of the results of experiment would prove its interest much more than any attempt to grasp a subject of such infinite intricacy.

Professor LEICHEART was anxious to find the cause of parasitism in the salmonidæ. They had in the salmon and trout family a group of parasites with the queer name of Echinorhynchi. By experimenting with gameri, he had actually succeeded in rearing with gameri in tanks, in an aquarium, the eggs of parasites which had come from the trout. He had fed these crustaceans with the germs which had come from the salmon and trout family, to such an extent that they actually succumbed from over-infection. There was here, therefore, an instance throwing a clear light on the means of infection of those fishes which formed that family. Now, what obtained in that case obtained in myriads of others, and it would be his business in the communication he had shortly to read, to set forth, in more clear and emphatic terms than he was able to do in those cursory observations, data on which the importance of this

subject in relation to the death and disease of fishes was based.

The CHAIRMAN, in putting the resolution, said he would make but two remarks: first to remind the audience of what Dr. Day had said, that the great majority of fish were carnivorous animals, feeding either on other fish, or on other marine animals of various kinds—he was speaking particularly of marine fish—so that they might be tempted to parody Peter Pindar's lines, and say that these fish have other fish to bite, and those fish other fish, *ad infinitum;* but that was not quite true, because in the long run you were brought down to the vegetable world, and probably the whole of the predaceous population of the sea depended ultimately upon those microscopic organisms known as diatomaceæ, which in the ultimate resort were the source of the greater portion of the protein compounds on which all animals had to live. It was a wonderful thing, if one considered the abundance of life in the Arctic Ocean, the prodigious quantities of carnivorous animals of all sorts which inhabited those seas—if you traced them step by step, the grampus feeding on the fish, the fish on the crustacean or on the mollusc, and the mollusc probably on some crustacean, or still smaller animals, but in the long run the ultimate store of food for all was in the prodigious quantity of diatomaceæ which occurred on the surface of the ocean, and by the help of some fish converted oxygen and ammoniacal substance into living beings. The only other point he would refer to, was the admirable principle Dr. Day had laid down, that before you abolished laws you should carefully inquire into their foundations. That was perfectly true: whether you were making laws or abolishing them, you should be very sure what you were

about; in fact, that was the basis of the great rule of common sense, never to act unless you knew what you were about, which was accepted by most persons in their senses, and if that rule had universal acceptance in fishery matters, he for one should not have had to offer so many criticisms as he had occasionally had to do.

The vote of thanks was carried unanimously.

MOLLUSCS, MUSSELS, WHELKS, Etc.,

USED FOR FOOD OR BAIT.

BY

CHARLES W. HARDING,

ASSOC.-M. INST. C. E.

CONTENTS.

Conference on Thursday, June 21, 1883.

THE Chair was taken at 2 o'clock by Mr. TYSSEN-AMHERST, M.P., who briefly introduced Mr. CHARLES HARDING, of King's Lynn, to the Congress.

MOLLUSCS, MUSSELS, WHELKS, ETC., USED FOR FOOD OR BAIT.

Whelks.—The Lynn fishery supplies about 20,000 bags, or 1,250 tons of Whelks a year, nearly all of which are used for human food. The average amount paid for them before the expense of boiling and carriage is about £10,000.

Whelks are caught in whelk-pots, which are small round baskets about 1 foot in diameter, with a hole in the top, through which the Whelk crawls, and is unable to return. These pots are sunk in from 5 to 30 fathoms of water, and baited with Crabs, Haddocks, and other fish.

The following places are the principal sources of supply: —Saltfleet, about 20 miles from Grimsby; Sherringham, by Cromer; Lynn Deeps, Docking Channel, Blakeney Coast, Wells, Boston Deeps, Brancaster, Thornham, and Hunstanton.

The Great Grimsby fishery supplies about 150,000 wash of Whelks annually. A wash contains 21 quarts and a pint, and the average price for the season would run about 3*s*. a wash, or a total of £22,500.

It is supposed that out of the 150,000 wash caught, not more than 6,000 wash are eaten; the other 144,000 are used for bait by vessels engaged in catching Cod, Ling, and Haddocks, each vessel using on an average voyage 45 wash, which in fine weather they would use in four days. The Grimsby smacks engaged in catching Whelks are fitted with wells, into which the Whelks are put after being first placed in nets; by this means they are kept alive, as they are almost useless for bait when dead.

The vessels used in catching Whelks are from 15 to 30 tons register, and some of the better ones cost from £600 to £700 each.

Most of the Whelks caught by Lynn smacks are sent to London for human food.

The edible Whelk is considered a very nutritious and strengthening food, and is always free from poisonous matter. I have heard fishermen say that a dish of Whelks does them as much good as a beefsteak.

I am indebted to Mr. D. Barnard, of Lynn, and Mr. W. G. Marshall, of Great Grimsby, for the above statistics concerning the Whelk.

I consider the only legislation necessary for the protection of Whelks is that the fishermen should return to the sea all Whelks less than 1¾ inch in length.

Mussels.—The most important mollusc, both for food and bait, is the Mussel.

In British waters, spatting usually takes place in the spring, and does not appear to be at all dependent on warm weather. On December 7th, 1877, I examined some of the embryo taken from a spatting Mussel with a microscope, and found it to have a reddish appearance, and about the five-hundredth part of an inch in diameter. It would not polarize, so I conclude the shell was not formed.

On the 12th December, 1879, I found large quantities of Mussels to contain similar embryos, the weather at the time being very severe. On December 3rd, 1880, I found the same. The winters of 1879-80 and 1880-1 were exceptionally cold, so that it appears they are not dependent on "heat and tranquillity" for their proper development.

On the 25th of May, 1879, after a very severe winter of about nine weeks' continuous frost, I found on one of the beds under my charge several acres of brood Mussels, about the tenth of an inch in length. In the spring of the year 1879, and the spring of 1880, overwhelming quantities of brood were found on the scalps on the east coast of England, which might be measured by hundreds of acres. There has not been a fall of spat since.

I found a few Mussels containing spat this year as late as the 3rd June; they appear to spat every year, but the spat does not always attach itself to the beds. It is probably carried away by the tides.

Where Mussel brood is found in thick and dense masses, they will be three years before they are what is called sizeable, that is, two inches in length; but instances are found near low-water mark where a few have become isolated, and have grown much more rapidly.

I do not think that Mussels will spat, or rather that the spat will mature, in partially-salt water. The only places where I have ever seen any young brood is where the water has the same degree of saltness as the outside sea, which on the east coast of England has a density of about 1026½; distilled water being 1000. Although it appears that salt water is necessary at their birth, brackish water is better adapted for fattening and growing, provided they are covered with the tide at high water. I find by experience that the most suitable degree of saltness of the water for

fattening purposes is where the density of the water is about 1014. This likewise applies to the fattening of Oysters.

To save the bulk of the spat when free is the great object of Mussel culture; therefore it is imperative to have the ground of the natural sea bed as free from sand, weeds, and mud as possible, so that the young may have some clean hard substance to which it can attach itself. Ascidians and sponges are very destructive to the young Mussel, as they cover the culch, which would otherwise be favourable for their attachment.

Mussels have a great many natural enemies, amongst which may be mentioned the Star-fish or Five-finger, the Dog-whelk (*Purpura lapillus*), the Sea Urchin or Echinus, sea birds, Danish crows, and sometimes rats; but Star-fish deal the most wholesale destruction. I have known ten acres of a thickly-covered scalp to be almost denuded in a fortnight. Last summer I had carted from beds under my control between two and three hundred tons of this fish. The Star-fish will always attack small Mussels in preference to those of larger growth. It first grasps the Mussel with its five fingers, and when it opens slightly to breathe and feed, it inserts its stomach, or part of it, into the body of the Mussel, when I believe digestion commences, and the Mussel dies and opens its shell, and the Star-fish withdraws its stomach with the meat of the Mussel. This operation I have seen performed in all its stages thousands of times, upon Oysters, Mussels, and Cockles.

The Dog-whelk bores a hole in the shell of the Mussel, about the size of a small pin-head, and destroys it.

The Sea Urchin also bores a hole in the shell of the Mussel, but much larger than the Dog-whelk, the hole being about the size of a sixpence. This very rarely

occurs. I have only seen three instances, and that on large Mussels near low-water mark.

Sea birds, Danish crows, and rats break the shell and devour the Mussel.

I consider the best and only way that existing natural Mussel beds can be properly cultivated and protected, is to make them the actual property of some one. If they are allowed to be fished indiscriminately, they will quickly become exhausted, as has been the case with hundreds of natural scalps on the coast.

Fifty years ago Mussels were very prolific on the East Coast of England, and almost every small harbour had its natural scalp outside, which fed the "lays" or fattening grounds inside, to the great profit of the owners of such lays. About that period some ill-starred individual discovered they were valuable for manure, when commenced a raid on the scalps, which is the origin of their present downfall. I can remember, as a boy, seeing hundreds and thousands of tons brought to land and sold to the farmers for manure, at three-halfpence a bushel.

An Act was passed by Parliament in 1868, called "The Sea Fisheries Act, 1868," which enables the Board of Trade to grant provisional orders to corporations and private individuals to regulate Oyster and Mussel fisheries; but the result, so far, has been very unsatisfactory. The reports of Mr. H. Cholmondeley Pennell, and Mr. W. E. Hall, two of the Inspectors of Fisheries, on the Oyster and Mussel fisheries, at eighteen different stations, show the beds to be worked in a very unsatisfactory manner.

Mr. Hall reports in 1877, that the Boston Corporation undertook to regulate the fishing in Boston Deeps in the year 1870, so as to maintain the supply. The Oyster beds, he states, remain in the state of denudation which charac-

terised them in 1869. The supply of Mussels, however, seems to be rapidly diminishing, from the persistent poaching of the fishermen, and from want of power of the Corporation under their "order" to close a sufficient portion of the ground every year. A similar "order" was granted to the Corporation of King's Lynn, in 1872. Mr. Hall reports on this "order" that the Corporation system of management in regard to Mussels is dangerous to the permanent welfare of the fishery; whilst as regards Oysters, the order is not carried into effect.

Under clause 4 of the order, the Corporation is compelled to keep open for fishing two-thirds of the area of the Oyster and Mussel beds, thus leaving a large proportion of the whole in a great measure at the mercy of the fishermen; and Mr. Hall justly points out the danger the Mussel beds of the Wash are necessarily exposed to from this provision.

When a Mussel bed is opened by either of the abovementioned Corporations, a day is fixed, and duly advertised, and at 12 o'clock at night, scores of boats commence taking the Mussels, some by tons, and some only by a few bushels. The next day the markets are glutted with small Mussels, and in some instances I have known them to be unsaleable. Even at the best they only make very small prices; whereas, if they had been gradually sent to the various markets, good prices would have been made.

I am the lessee of about eleven miles of sea-beach on the Norfolk Coast, belonging to Hamon Le Strange, Esq., whose title to the proprietary right descends from a grant made in the eleventh century by William II. to William d' Albini, his butler.

The fishing on this beach consists of Mussels, Cockles, Clams, Winkles, and a few Oysters.

When I hired the fishing, eight years ago, there was not one ton of Mussels on the whole eleven miles. I appointed watchers, enforced a close time, cleaned the ground, and endeavoured to keep off poachers, but with very indifferent success. Mr. Le Strange, in 1879, applied to the Board of Trade for the grant of an order for the establishment and maintenance of a joint Oyster and Mussel fishery, under the powers of "The Sea Fisheries Act, 1868," so as to provide a better protection for the fishery. The Board of Trade sent an inspector down to hold an enquiry as to the proposed order, and in June this year the order received the Royal assent, rather more than four years after the first application, at a cost of several hundred pounds, owing to the Board of Trade refusing to define the boundary of an adjacent fishery to which they had previously granted an order.

This order will greatly benefit the long-line fishermen off the coasts of Northumberland and the South of Scotland, as I have special railway rates to all the ports on these coasts, and can afford, when I have any Mussels, to deliver them at a reasonable price for bait. The importance of Mussels for bait to these deep-sea line boats is incalculable.

Mr. P. Wilson, late Her Majesty's Fishery Officer at Eyemouth, in Scotland, reports that in one week the boats from Burnmouth, Coldingham and Eyemouth used for baiting their long lines, sixty-one tons of Mussels. They landed, with this quantity of Mussels, 25,620 stone of Haddocks, besides a considerable quantity of Cod and Whiting, and got for the fish 1*s.* 8*d.* per stone, equal to about £2,500. Observe, in one week alone, sixty-one tons of Mussels were used at these three fishing-stations for bait, the cost of which was about £160, the produce in fish

from which was 25,620 stone, worth £2,500. Mr. Wilson also reports that when the fishermen are unable to obtain Mussels, they have had to bait their lines in many instances with bullock's liver, and be content with half a catch of fish.

The greatest trouble I have in protecting my Mussel beds is from a class of men who call themselves fishermen, but who are half farm labourers and half fish hawkers, and are the scum of the villages bordering on the coast. I have lost from two to three thousand tons of Mussels in one year by these men, which would otherwise have gone to Scotland to be used as bait by real fishermen. All of this might have been prevented had the Board of Trade granted a provisional order for this fishery when requested. Taking Mr. Wilson's figures, that sixty-one tons of Mussels will catch £2,500 worth of Haddocks, Cod, and Whiting, one thousand tons of Mussels would catch about £41,000 worth of fish.

Mr. John Doull, who succeeded Mr. Peter Wilson as Her Majesty's Inspector of Fisheries at Eyemouth, writes to me on the 31st of May last as under:—

"I am not aware of any of the fishermen in this quarter using Whelks as bait. At some places on this coast Whelks are gathered and despatched to inland towns for food.

"Limpets are, however, collected in large quantities, and used by our fishermen on their lines along with Mussels.

"Fishermen inform me that Mussels will keep alive for three hours in water after they are taken out of the shell, but speedily die when placed on the hook.

"To increase the supply of Mussels, I think that leases of suitable portions of foreshores should be granted to

persons who may be desirous of cultivating Mussels thereon, for which no rent should be charged until it would be seen whether the venture would be successful.

"The cultivation of the Mussels to be subject to the supervision of a Government Inspector, to see that it is properly attended to.

"The supply of Mussels to our line fishermen is of vital importance to them. For instance, here in Eyemouth alone, where twenty-eight boats, manned by seven men each, prosecuted the line fishing for Haddock from October last until now, no less than 920 tons of Mussels were used by them in that period, costing nearly £1,800 to the fishermen, about one-half of which sum was expended on the carriage of the Mussels.

"These twenty-eight boats grossed on an average for the season upwards of £600 each, still the item of Mussels bulked largely in their expenditure.

"The 28 Eyemouth boats shot their lines 2825 times during the fishing season ended May 1883; each boat carries 7 men and 7 lines, but on Mondays 10½ lines; each line is 1200 yards long, so that the total length of lines that passed through the fishermen's hands during the season was 15,200 miles, or a length that would extend to about two-thirds the circumference of the earth.

"Every day the boats proceeded to sea they shot 135 miles of lines, and on Mondays 202 miles. On each line there are 1050 hooks, and every time the boats were at sea 205,800 hooks, baited with 411,600 Mussels, were put into the sea. The total number of Mussels used during the season, averaging two for each hook, was 46,819,500: exclusive of this enormous quantity of Mussels a good deal of Limpets were used, and also some bullock's liver. Nearly all the Mussels come from the Wash or the

Boston Deeps; a very insignificant portion was from Newhaven and Ireland.

"No better fishermen than the Eyemouth men are to be found anywhere; they are noted for their industry, perseverance, and energy, and I certainly do not know of more hardworking fishermen on the Scotch coast than those of Eyemouth.

"The white fishing trade seems to be undergoing a great revolution in consequence of the steam trawlers.

"Yours faithfully,

"JOHN DOULL."

I consider that, where natural beds of Mussels have once existed, and the ground has not altered, there new Mussel beds may be established and cultivated; but the Government must grant provisional orders to persons desirous and willing to take in hand the cultivation of Mussels and Oysters, and not allow the officials at the Board of Trade to prevent the granting of such orders. The orders must enforce heavy penalties on persons illegally taking the molluscs, and provide for the imprisonment of those people who are unable to pay the fines and costs, as the greatest amount of poaching is done by the impecunious inhabitants of the villages adjacent to the shore, and whose forefathers a hundred years ago were the wreckers and smugglers of that age. Illegally taking Oysters and Mussels from such a fishery should be felony.

Mussels are largely cultivated on the continent. The exports from Antwerp for Paris alone, as recorded in the "Halles Centrales" Statistics for the season of 1873 amounted to seven million francs (£280,000). This represents the produce of natural beds and scalps unimproved by man's care.

In the town of St. Valery-sur-Somme, in France, artificial breeding, rearing, and fattening of Mussels, upon principles akin to those which obtain in ostreaculture, is carried on, and the success attained is such as to be worthy of a record in the history of attempts made to utilise the unbounded wealth of food lying ready to man's hand along the sea-shore. Lines of wattled stakes, averaging 530 yards in length, are driven in the sand close to the fair-way, just above low water-mark. These *bouchots de grand flot*, as they are called, extend over twenty-five acres. They serve for fixing the spat, which is floated up to them by the tidal currents, and constitute a collecting ground for brood, which are afterwards removed into shallow tanks of about fifty acres, dug out high on the strands between the tide marks. They are puddled with clay, and fitted with sluice-gates. The salt water in these tanks is slightly admixed with soft river water. They also serve as nurseries for the young Mussels, which hang in clusters and gather on wattles. When they attain proper size for transplanting, they are removed into the *parc*, where they will grow and develop into marketable Mussels. All this is being successfully carried out by M. Lemaire, who obtained from the French Government, in 1873, leave to appropriate a small strip of 40 acres of the foreshore fringing the low sandy estuary of the Somme. The success of this short experiment was so marked, that after an official visit paid by the Minister of Marine, and a number of *savants*, including M. Coste, who had predicted a failure, the original concession was extended to 620 acres.

There are numerous other places on the Continent of Europe where Oyster and Mussel culture is successfully carried on.

The secret of the whole matter is, where Mussel and

Oyster culture has proved successful, that the person undertaking the same has obtained a concession from the Government to work the beds exclusively himself, and has not been hampered by other persons claiming a right to fish on his grounds; in other words, fishings are worked in precisely the same way as farms, where the farmer sows his seed, and at the proper season reaps his corn.

In England the laws allow the seed to be sown and protected to a certain extent, and when the molluscs are a certain size (*i.e.*, two and-a-half inches for Oysters, and two inches for Mussels), the whole world is free to come and fish on the beds by taking out a nominal licence, which is at the rate of 3*s.* 6*d.* per ton on the burden of the smack for one year, or 9*d.* per ton per month. This applies only to fisheries worked under the "Sea Fisheries Act, 1868."

To make the Oysters and Mussels the actual property of some private individual or body corporate appears at first sight to be rather hard on the so-called fishermen; but it must be borne in mind that any person who undertakes to properly cultivate a portion of the foreshore for the increase of Oysters and Mussels must be in a position to expend a certain amount of capital, and therefore he would not very probably do much manual labour, but confine his energies to the employment of watchers or water bailiffs, to the making of "lays" or "parcs," by digging large reservoirs between tide marks, and the various other expenses contingent upon the enterprise; so that the supply of molluscs would be greatly increased, and the fisherman or labourer employed would have more work than he has under the present exhausted state of things.

Under the "Orders" granted to the Corporations of Lynn and Boston for the cultivation of Oysters and Mussels, they have collectively jurisdiction over 229 square miles in

the Wash; and I have no hesitation in saying that, if the Mussel beds in this area were properly worked, they are capable of supplying with bait the whole of the long-line fisheries of the country.

To catch the Mussel spat I have tried rows of wattled stakes placed in different positions on the beds as in France, but I found that they became covered with a green weed in a very short time, and were therefore unable to receive the spat.

I found that rows of stakes or blocks of cliff stone placed on the scalp remained free from weed and gathered the spat.

Mussels are used very largely for food in London, Manchester, Birmingham, Nottingham, Leicester, and other towns, the supplies coming from the Wash, Morecambe Bay, Devonshire, and large quantities from Bruinisse in Zeeland.

The Mussel is admitted on all hands to be the most deadly bait for salt-water fish, and from experiments I have made I believe the reason to be attributable to its tenacity to life. A Mussel taken from its shell and suspended on a hook in sea-water will be alive in two days. I am aware that fishermen are under the impression that they die shortly after being placed on the hook, but that such is not the case I am certain; the microscopic movement of the cilia on the four gills or branchiæ may be overlooked by a fisherman, but undoubtedly this lifelike movement is appreciated by the fish, and causes the Mussel to be the most deadly of baits.

The Mussel beds on the east coast of England are capable of supplying with bait the whole of the line fishing. The method of obtaining this bait up to the present has been for the Mussels to be sent from the Wash and other

places by rail and by fishing smacks, in the winter time when they are wanted. The railway rates to the Northumberland and south Scotch ports vary from 20*s.* to 23*s.* 4*d.* a ton; in addition to this there is the cost of carting from the natural scalps, some distance to the nearest station.

I consider a great improvement might be made upon this by selecting suitable sites on the foreshores of the estuaries in the north of England and the firths of Scotland, and sending the Mussels to the north during the summer months, as small steamers, which will not run in the winter, will take them to the north for about 8*s.* to 10*s.* a ton during the summer months. This would decrease the cost of Mussels to the fishermen at least 20*s.* a ton.

DISCUSSION.

Mr. EARLL (of the United States Commission) said he had enjoyed the paper very thoroughly, and had gathered much valuable information from its details. He could see that it had required very careful research to collect the information which it contained. He was not specially familiar with the shell-fish fisheries of Great Britain, but, as he understood it, one of the principal objects of these Conferences was a presentation of facts which would be valuable to foreigners in regard to the fisheries of Great Britain, and, on the other hand, of facts in regard to other countries, which would be useful to the inhabitants of Great Britain. They had learned, during the morning discussion, of certain fishes that might be of importance to Great Britain, which had not yet been introduced, and of others which, though already introduced, were regarded as decidedly injurious, and it seemed to him that one of the principal objects to be attained was definite information

on these points. He had recently learned from Captain Danewig, of Norway, that the soft clam (*Mya arenaria*) was very abundant on that coast, but that was not used either for bait or as food. He inferred that the same species was abundant on the British Coast—if he were mistaken on this point he should be glad to be corrected, but he thought the inference was that there were large quantities. In the United States they made very little use of mussels, although there were large quantities of them: the fishermen did not use them for bait, and the people, excepting a few in the vicinity of New York, knew nothing of their value as food. They substituted the soft clam, of which the people of Norway and Great Britain had not yet learned the value. Since coming into the room, he had hastily put together a few facts concerning the extent to which this species was used in the States. In the State of Maine 318,000 bushels, or 1,000,000 lbs. of this mollusc were used for bait and for food. In Massachusetts an equal quantity, if not more, and in the middle states 406,000 bushels, making in all over 1,000,000 bushels, having a value to the fishermen of \$458,000. He had not the statistics for Connecticut, Rhode Island, and some of the other States where these shell-fish were also used in considerable quantities, but including them it might be said that over 1¼ million bushels, valued at probably not less than \$600,000, were used on the Atlantic sea-board. Some fishermen on the coast confined themselves to the quarrying, as it was called, of these shell-fish, for they had the habit of burying themselves two or three inches deep in the mud or sand of the shallow bays along the shore. This industry afforded employment to a large number of fishermen at a time when there was nothing else to be done. Some of the smaller vessels, not considered

safe to encounter the winter gales, were taken into the shallow waters, where they served as hotels and work-houses for the men engaged in quarrying the clams. These men spent two or three months in gathering a vessel load, shelling and salting them, to be sold in the early spring to the vessels engaged in the great ocean cod fisheries; whilst large numbers were also engaged, during the entire summer, gathering them to be sold in the larger markets for food, where they were prized very highly, not only by the labouring classes, but by the best people of the country. It appeared to him that the people of Europe had at their doors a large resource wholly undeveloped, and he should be very glad if, by calling attention to this question, he should in any way assist in adding to the stock of food, or to the readiness with which fishermen might procure bait.

Dr. DAY said he had made some inquiries with regard to the mussel fisheries last year when in H.M.S. *Crichton* on the east coast of Scotland. It had been suggested by Mr. Harding that the mussel beds should be granted to private individuals to work, because if they were left open to the fishermen they would work them out until nothing was left. But then a difficult question came forward. If these mussel beds were granted to private individuals, how were the fishermen to get their bait? They complained that when mussels were in the hands of private individuals, the charge was so great that they could not get bait for fishing. If any or all of these beds in one locality were given to a private individual under Government supervision, it ought to be on the distinct understanding that the mussels were forthcoming at a certain price, not a prohibitive one, and that the fishermen could have them at any time.

Mr. SAVILLE KENT had listened with great interest to this Paper, and thought the statistics would be of the utmost service; he also felt indebted to Mr. Earll for his notice of soft clam, which there was no doubt did exist abundantly on the coast of England, and might be utilised as it was on the coast of France. There were also half a dozen other species on the east coast, and which might be equally utilised as the food of man. They were mostly bivalve molluscs, and amongst them might be mentioned the bastard oyster, which was generally considered an enemy to the other oysters, because it filled up the places where they were cultivated. It was used, however, on the south coast of France, and might be equally used here. There was also the *Donax pentaculus* and *Venus mercenaria*, and the razor shell, which were all estimable food, and were appreciated on the coast of France and most parts of America.

Professor BROWN GOODE said the remarks of his colleague, Mr. Earll, about the distribution of the soft shell food clam, and the manner of its capture, reminded him of a subject which was frequently proposed for discussion at the debating societies and schools in America, viz., Is digging clams fishing or agriculture? It was the fact that along the entire coast of New England the agricultural population in many instances derived half their support in digging, with hoes and shovels, clams of various species. Mr. Earll had spoken of the *Mya arenaria*, but there was another species on the coast equal in abundance, the round clam, called also by the Indian name quahang, and sometimes called the wampum clam, because it was the shell from which the Indians made money; broken fragments of the shell were strung on bits of skin, and used as a medium of exchange. Then the *Venus mercenaria* also occurred

everywhere from Cape Cod to Florida. Its production was almost equal in extent to most other species. Mr. Earll had estimated the value of the soft shell clam at about $700,000, and he thought the production of the round clam must be equal, or nearly so. When small it was considered a great delicacy on the dinner-table in the summer months when oysters were not in season. He was led to refer to this species from the fact that Mr. F. G. Moore, Curator of the Liverpool Museum, placed in his hands the other day a paper in which he described a successful experiment of the introduction of this round clam into the waters of the St. George's Channel, and he hoped it would take root here and become useful. There was another species closely resembling this, the sea clam, or hen clam (*Macter solidissima*). It was also abundant on the sandy shoals, and afforded bait to fishermen to something like $30,000 or $40,000 a year. This also might be introduced with advantage in the North Sea. Many species in America, as, for instance, the mussel, the whelk, the cockle, and the little *littarina* (the common name of which he did not know), were exceedingly abundant, but were not gathered by fishermen to any extent. He had great pleasure in moving the vote of thanks to Mr. Harding for his Paper.

Alderman SMETHURST (Grimsby) had great pleasure in seconding the motion. He said he was aware of the difficulty of blending instruction and entertainment together to the satisfaction of an audience, and this seemed to be more a question to be reasoned out amongst a number of gentlemen practically acquainted with it in Conference, than to be talked about in a General Assembly. Speaking of bait, they all knew what was most suitable for their own localities in fishing, and the bait used differed considerably

in different localities. In some parts they used mussels for fishing along shore within sixty or seventy miles of land, but when they got beyond that they used different kinds of fish for different seasons. When they got on to what was called the "shawl" of the Dogger Bank, in the spring of the year, when the fish began to accumulate in the warm weather, they used whelks, when they went down at the fall of the year to the north end of the Dogger deeper water, they began to use lamprey eels along with whelks, to assist in catching two or three kinds of fish which harboured there; as they extended further across the sea the bait was changed again, according to the season of the year, and the depth, and the clearness or thickness of the water. In some parts they used lamprey eels for clear water, but when they got to about two hundred miles away, they then took what they considered a different class of bait to fish in deeper water. There they caught cod, ling, halibut, skate, and haddock. The bait used was lampreys, as a rule, and later on herrings. In clear water the herring was the most suitable fish; in thick water they used whelk bait, on account of the smell, which attracted the fish when they could not see it. In the summer time, when on what they call the Little Fisher Bank, they used herring principally for taking large halibut and ling. At this particular time of year they were fishing close to the coast of Norway on the stony ground, a place which he and his two sons opened out four years ago. They were now on the ground using mackerel for taking halibut weighing from 7 lbs. up to 16, 18, and 20 stone. They used vessels carrying 6 and 7 tons of ice each, and they were employed for seven or eight months in the year. Grimsby might be considered the largest fishing port in England. It received upwards of 100,000 tons of fish in a

year. The whole of this was not sent into the country for food, but part of it was used for bait, whilst a great part came to London, Manchester, Liverpool, Birmingham, and the large manufacturing towns. It was very right that this shell-fish should have every care and culture, and should not be allowed to be wantonly destroyed, because fishermen must have bait before the fish could be caught, and if the brood of the mussel were destroyed, and the whelks, the amount of fish caught would be greatly affected, and if it even became scarce and dear, people would have to pay a greater price for the fish they eat. The great cry everywhere now was how to get cheap fish into London, and that was a question to which he had devoted all his energy for the last thirty years, and had given his opinion when on the Commission which sat in London some three years ago.

The motion having been put and carried,

Mr. HARDING in reply, having thanked the Congress for the manner in which the Paper had been received, said there were few clams in England. On the coast which he hired, of about five miles, the men did not get a dozen in a day. With regard to the restrictions of price, he could only say that he had several thousand tons of mussels suitable for bait, and could not dispose of them at any price.

Mr. BIRKBECK, M.P., then moved a vote of thanks to Mr. Tyssen-Amherst for presiding. He felt specially indebted to him, being the representative of one division of his own county, where this question was one of great importance.

Mr. TOLLEMACHE, M.P., in seconding the vote of thanks, said, although there had not been so large a meeting as he had hoped, there had been a most interesting discussion.

The vote of thanks having been carried unanimously,

The CHAIRMAN said it was a great pleasure to him to associate himself with the subject of this Paper, in which so many fishermen on the coast took an interest. The mussel did not make a great stir in the world, like many of the fishes, but it was not to be despised on that account. He asked Mr. Harding just now whether any pearls were found in the mussels on our coast, but he informed him there were not, but there were some in many of the fresh-water mussels. If he mistook not, when he was at Conway, where there are thousands of mussels, he was informed that pearls were rather numerous. The discussion had been of great interest, showing the different kinds of molluscs that inhabited various parts of the coast, and also that many which were not appreciated here were set great store by in foreign countries. In human affairs it often happened that small things were overlooked, and, like the mussels which were trampled upon on our shores, had to go to the wall; but Providence ordained that they performed in a humble way a very important function, and, with the great monsters of the deep, contributed to what was so well represented in the Exhibition, the harvest of the sea.

THE ARTIFICIAL CULTURE OF LOBSTERS.

BY

W. SAVILLE KENT, F.L.S., F.Z.S.,

AUTHOR OF 'A MANUAL OF THE INFUSORIA;' LATE ASSISTANT IN THE NATURAL HISTORY DEPARTMENTS OF THE BRITISH MUSEUM, AND PRACTICAL CURATOR AND NATURALIST TO THE BRIGHTON, MANCHESTER, AND WESTMINSTER AQUARIA.

CONTENTS.

Conference on Monday July, 23, 1883.

John Tremayne, Esq., in the Chair.

THE ARTIFICIAL CULTURE OF LOBSTERS.

One of the most important objects of the Conference held in connection with the International Fisheries Exhibition is, I anticipate, to elicit data that may be utilised for the improvement or resuscitation of our many fishing industries already established, and for the opening up of new fields that may give employment to the fishing community, and increase the supply of wholesome food for the use of the masses.

Taking this for granted, I here propose to submit to you the results of some practical experiments made on my part some few years since, in connection with the artificial cultivation of lobsters, trusting that the deductions I have arrived at with relation to the same may contain, at least, some crude ideas that may be hereafter fashioned into shape and prove of utility to the public.

The lobster, I need scarcely remark, occupies a front position in the ranks of our food fishes. Its intrinsic value, weight for weight, is little inferior to that of salmon, while its nutritive and restorative properties as an article of diet, are, in accordance with the latest dictum of the medical faculty, vastly superior. An idea of the inadequacy of the

supply of this crustacean, obtained in British waters, to meet the public demand, may be gained from the statistics contained in the Government Report upon the Crab and Lobster Fisheries, published in the year 1877. Herein it is shown that, upon an average, no less a number than one million of lobsters are imported annually into the United Kingdom, in the living state, from Norway alone, which is the chief source of our supply, this million, at the date quoted, representing a money value of about £22,500.

Statistics are likewise here given of the numbers of lobsters annually derived from different portions of the British coast line, the keynote and burden of the whole report being, however, the unwelcome, but only too familiar intelligence, that lobsters are continually becoming scarcer and dearer, and that the fishermen have, year by year, to go further afield, dividing the large profits, once accruing to the few, among the many, to meet the requirements of the market. The lobster, not many years since within easy reach of all members of the community, is in fact rapidly following the lead of the native oyster, and threatens soon to be a luxury at the disposal only of the wealthy. A quotation from the report already referred to will suffice to establish this assertion. Here is the testimony we find on many a page. England and Wales: "Crabs and lobsters are decreasing; they are overfished." "The grounds in-shore have been fished out, and the men have to go to deeper water." Scotland: "A very large majority of the witnesses, with special means of arriving at a just conclusion on the subject, are satisfied that the crab and lobster fisheries of Scotland are in a state of gradual decay." Of Norway, our richest source of supply, a Mr. Fisher, one of the Billingsgate salesmen most extensively engaged in the Norwegian lobster trade, gives evidence thus:—"The

supply has fallen off during the last seven years. Ten or twelve years ago he used to import 600,000 lobsters a year from Norway, from three districts only. He is now working six districts, double the amount of coast, and the six districts only produced last year from 400,000 to 500,000 lobsters." Other evidence elicited by the Commissioners resulted in their verdict that "there is little room left for doubting that there has been a very serious falling off in lobsters in Norway."

The causes that have contributed towards the decadence of the lobster fisheries generally are relegated in the report to three distinct categories. 1. The overfishing of the inshore districts. 2. The destruction of undersized fish. 3. The consumption of the eggs or spawn for culinary purposes. For the second only of the evils thus summarised—that of the destruction of undersized fish—has a remedy been actually applied, and beyond doubt with highly beneficial effects, through the appointment for lobsters of the eight-inch gauge, fish within which length, by the Act 40 and 41 Vict. c. 42, 1877, are now of illegal size. The suggestion of a close time for lobsters during their spawning season, to prevent overfishing and to protect their eggs, has not been found practicable, since it would, in the first place, interfere unjustly with the inherited rights of the fishermen, while, in the second instance, it would interrupt the supply at the period when lobsters are, as an article of food, in their very best condition.

Assuming for the time that both the protection of the undersized young and that of the adults, during the spawning season, had become binding by law, I feel justified in asserting that we should have, even then, only arrived half way towards the root of the evil, and that the prime factor in the decadence of our lobster fisheries is to be found in

the permitted wholesale destruction of the lobster's spawn. Comparing matters with the law as it now exists, with relation to the trout and salmon fisheries, the foregoing regulations, if enforced, would, in fact, leave us in precisely the same position as obtained with these important industries prior to the introduction of the artificial system of cultivating and protecting the eggs and fry of the Salmonidæ. To all who have given attention to this subject it is a well-known circumstance that, but for the introduction of the artificial system of culture on the part of patriotic pisciculturists, our lakes and rivers would never have recovered from the exhausted condition to which they had been reduced by overfishing. Now, what has been achieved in connection with the Salmonidæ I am prepared to maintain is capable of realization with the lobster tribe. That lobsters may be artificially cultivated from the egg I have already proved by practical experiment on a small scale, and to demonstrate that the same principles applied upon a wholesale one might be utilized for re-stocking our exhausted inshore fisheries is the chief object of this communication.

In order to place you fully in possession of the circumstances and capabilities of the subject introduced, it is desirable that I should give you a brief sketch of the early life-history of the lobster. As is familiar to all present, the eggs of the lobster, upon extrusion, are attached in masses to the filamentous appendages, or "swimmarets" of the abdomen, or so-called "tail" of the lobster, and constitute what is popularly named the "Berry." The amount of eggs extruded by the female fish, it is singular to observe, coincides remarkably with those of the salmon, numbering from 20,000 to 30,000. Attached beneath the parent's abdomen, in the form of "berry," the eggs remain for a period of three or four months, and then the young

are hatched. No nutritive or other than a purely mechanical relationship subsists all this time between the parent and its egg-clusters, the passing of its small brush-like claws among them to rid them of any extraneously derived substances, and the occasional fanning motion of its swimmarets to increase the stream of oxygenated water through and among the eggs, representing the sum-total of attention they receive.

The young animals that issue from the eggs of the lobster are distinct in every way, including shape, habits, and mode of locomotion, from the adult. If, on the contrary, they were born like their parent, they would at once sink to the bottom of the water in the immediate neighbourhood of their birthplace; the area of their distribution under such conditions would be extremely limited, and through close interbreeding, it may be anticipated that the stock would become materially deteriorated. Nature, here, however, as in the case of the great majority of marine invertebrate animals, has provided her offspring with special facilities for becoming distributed to long distances, their bodies being so lightly constructed that their specific gravity scarcely exceeds that of the fluid medium they inhabit, while they are additionally provided with long feather-like locomotive organs, with which they swim at or near the surface of the water. As such essentially free-swimming, pelagic animals, they now spend the entire first month or six weeks of their existence, in which time, it is scarcely necessary to state, they may be carried by the tides and currents many miles away from their place of birth. During this interval, however, the little lobsters by no means retain their primitive shape; their delicate chitinous skins, the rudiment of the future shell, is constantly getting too tight for them, and is thrown off to give place to a larger and

looser one, that differs each time in many structural points from its predecessor. As determined by my own experiences, such a changing of the skin, or "ecdysis," as it is technically termed, is effected no less than half a dozen times before the little animal arrives at the ambulatory condition, and takes upon it the form and features of the parent. This chapter in the life-history of the young lobster is of the most interest, perhaps, when studied by aid of the recently kindled, but ever-increasing, light of the doctrine of evolution. In its onward progress towards the form and proportions of a typical lobster it is thereby found to pass through conditions that in former times were regarded as distinct animals belonging to less highly organised groups of the crustacea than the parent animal.

Thus, when liberated from the egg, the little crustacean, designated a "Zoea," has no abdominal appendages, and swims through the water by means of the external branchlets, or "exopodites" of its thoracic limbs, and in this respect resembles the so-called Opossum Shrimp (*Mysis*) referable to the order Schizopoda. This condition is maintained through several successive skin-castings, or ecdyses, the abdominal appendages, or swimmarets, however, gradually developing, and the thoracic swimming organs becoming simultaneously reduced. At or about the sixth cast these last-named structures have entirely disappeared; the little animal swims through the water with the aid only of its abdominal swimmarets, and is to all intents and purposes a small prawn (*Palæmon*). The internal elements, or "endopodites" of the primarily bifid thoracic limbs have, meanwhile, developed into true legs, so that, after the manner of a prawn, the young lobster can either walk upon the ground or swim in midwater. It is with the next ecdysis only that the animal becomes a typical lobster, re-

stricted to an ambulatory mode of existence, or capable of spasmodic translation only through the water in a backward direction through the flapping action of its spreading tail. Did we trace back the developmental phases of the lobster to a period before it had left the egg, we should find that for a while it represented a much lower type than an Opossum shrimp, or prawn, it having then but three pairs of jointed appendages, and corresponding in this respect with what is known as the primitive larval or "nauplius" condition of all crustacean life.*

Interesting as these developmental phenomena of the lobster are shown to be, the chief object of my bringing them before your notice is to impress upon you the fact that, during the first three or four weeks, at least, of its existence, the lobster is so small and helpless, and so exposed to surrounding perils, that a very infinitesimal percentage only of each liberated brood can hope to run the gauntlet of its numerous enemies, and to settle down to the bottom of the sea as an ambulatory lobster. Gregarious shoals of full-grown fish, such as herrings, atherines, and sand-eels, subsist almost exclusively upon pelagic crustacea, be they the adult phases of smaller species or the larval conditions of larger types, such as crabs and lobsters; while the young of almost every fish that swims, in addition to a host of marine invertebrate animals, are addicted to a similar diet. The risks that a lobster runs during the first few weeks of its infancy, are, in fact, as great, or, indeed, greater than those encountered by a young salmon, in its native streams, during its egg and "alevin" conditions.

* Certain, but not all (see Addendum, p. 343), of the several growth-phases of the common lobster here described have, on all substantial points, been likewise independently observed in France by M. Gerbe, in Norway by Professor Sars, and of the American variety by Mr. S. J. Smith.

Now all present will, I think, admit that that day on which it was found possible to protect and rear these infant salmon, until they were fit to shift for themselves and be turned into the river, constituted the turning-point in the downward career upon which our salmon fisheries, up to within a comparatively recent date, had entered. But for this discovery, that the eggs and young of the Salmonidæ might be artificially reared and protected, and in spite of all rules and regulations concerning a close time and the protection of undersized fish that had been established, our best salmon and trout streams would by this time have been literally ruined.

Now, gentlemen, the very important proposition that I have to submit to your consideration is, that the eggs and young of the lobster are, as compared with the salmon, equally susceptible of artificial cultivation, and you will agree with me, I think, if I can substantiate this statement, that the resuscitation and restocking of our exhausted lobster fisheries are brought within, at least, a measurable distance of accomplishment. Nothing short of evidence of the most practical description will, I am aware, assist me in substantiating the position I have undertaken, and such evidence I will now place at your disposal. At many of the large public Aquaria with which in former years I have been associated as naturalist, berried lobsters have brought forth their progeny in the tanks. On most of these occasions the fate of the little lobsters has been to either perish for want of suitable nutriment or to be eaten up by the other fish. Notably, however, in the year 1875, at the Manchester Aquarium, I observed of a newly-hatched brood that they assembled like a cloud of gnats and fed freely upon the finer particles of minced fish thrown into the water as food for the ordinary occupants of the tanks.

It was the observation of this phenomenon that suggested the possibility of rearing them artificially. Examples were accordingly removed, placed by themselves, and fed at regular intervals with the food for which they had displayed a partiality, the upshot being that a considerable number of them were reared through the several metamorphoses previously described, and until, in fact, they had become fully formed ambulatory lobsters measuring about one inch in length. Specimens of these little lobsters thus artificially reared I have the honour to submit to you.

It remains for me to state that the experiment, thus brought to a successful issue, was accomplished in the roughest and rudest manner. The little animals were merely placed, a number together, in glass jars having each a capacity of about one quart, the sea-water contained in them being simply changed each morning. Such crude efforts on a small scale being rewarded with success, it is not only probable but it may be maintained as a reasonable and logical deduction, that the culture of young lobsters on a very much larger scale, and with the aid of all those perfected appliances and experiences that have been brought to bear upon the hatching and rearing of Salmonidæ and other fishes, would be easy of achievement. The period during which the young lobsters would require attention, dating from the time of their exclusion from the egg until they attain to the ambulatory state, is represented by an interval of but a month or six weeks, and the amount of food each individual lobster will consume in that time does not exceed one or two ounces. The ambulatory state arrived at, the little animal, though not exceeding an inch in length, is perfectly fit to shift for itself, and, like a young trout or salmon of the same size, on being consigned to the water immediately goes to the bottom and seeks to hide itself beneath

the stones or any suitable shelter that may present itself.* The rearing of lobsters in thousands instead of in tens or units would, it is needless to assert, be but a matter of augmented apparatus, and what the results would be upon our depopulated lobster grounds if several thousands, or rather millions, of such young animals could be turned out upon them annually, those are best qualified to record a verdict who have already had practical experience in the cultivation of Salmonidæ.

Certain details respecting the suggested culture of lobsters on an extensive scale, and having such a practical end in view as the restocking or improvement of our home fisheries, may now be proceeded with. In the first place, the simplest method of obtaining the young lobsters to be reared is doubtless to keep the berried hens in suitable ponds or tanks until the young are liberated from their eggs. This process, though a sure one, necessarily entails the feeding of the adult fish for a period of several months while their eggs are ripening, and this expense, in my opinion, might be avoided. As explained in an earlier paragraph of this Paper, the relationship maintained between a female lobster and her eggs is a purely mechanical one, for the purpose of securing their protection, aeration, and freedom from extraneously derived substances until the young are hatched. Now all these conditions could be as efficiently secured by an artificial system of culture, almost precisely identical with that which has been brought to bear so successfully upon the cultivation of the eggs of the Sal-

* Although not frequently obtained close to shore in this very early ambulatory condition, my friend Mr. Henry Lee, F.L.S., tells me that he has, many years ago, taken such little lobsters, having an average length of from one to one and a half inches, in the neighbourhood of Shanklin, Isle of Wight.

monidæ and other fishes. The eggs of the lobster might be similarly spread out upon trays or grids, allowing the free percolation of well-oxygenated water, and intelligent supervision being at hand in the same way to remove all dead examples or other deleterious matters. Or nature itself would be yet more nearly imitated if the groups of eggs, numbering many hundreds, as attached to the swimmarets of the parent, were bodily removed, and by some simple device suspended in grape-like clusters within the midst of the circulating currents. The young lobsters being hatched, they will be found to thrive best in deeper receptacles where they will have abundant room to swim. The font-like rearing troughs introduced by Mr. Oldham Chambers, F.L.S., the goblet-shaped glasses utilised by the Canadian pisciculturists, but more especially the larger glasses on the "intermittent syphon system" and other hatching receptacles for floating spawn made use of by the United States Fisheries Commission, may be cited as being particularly suitable for lobster rearing.* Feeding the young brood is obviously a mere matter of mechanical detail, finely-minced fish or mussels being the most convenient pabulum. Whatever is decided on, due attention must be paid to the food being supplied abundantly and regularly, otherwise they will fight and devour one another. The well-known pugnacity and reputed cannibalistic tendencies of lobsters and other crustacea has been supposed

* I here take the opportunity of acknowledging the kind courtesy shown me by Mr. Earll of the United States Fisheries Commission in introducing and explaining to me the very complete collection of hatching and rearing tanks exhibited on behalf of the United States Government in their department of the International Fisheries Exhibition. Such inspection, it may be added, resulted in that gentleman's concurrence with my own opinion, that the receptacles on the "intermittent syphon system" were especially adapted for lobster culture.

by some to present an insuperable obstacle to the cultivation of lobsters in quantities. Where, however, an abundant supply of other food is forthcoming it will be found that they prefer it to their own species; and I need hardly remark that cannibalism where animals are reduced to a state of starvation is not, as a moral attribute, monopolised by the crustacea.

Once reared through to the ambulatory condition the little lobsters are fit for liberation in their native element, and here care must be exercised in the choice of the ground upon which they are turned out. That of a flat sandy nature affording no shelter, and where they would be speedily sought out and devoured by their numerous enemies, should be avoided. Rocky ground, which is their natural haunt and from whence, as is well known, the most abundant supply of lobsters is derived, is that on which they should be set free. Arriving at the bottom of the water they will, as previously observed, immediately seek for a suitable crevice wherein to hide themselves, and this having been met with it is adopted as their permanent abode, to which they will constantly retreat after their sorties in search of food, which are usually made at night. This selection by lobsters of a definite dwelling place is a well-known circumstance to fishermen and others practically acquainted with the habits of marine animals. It may be cited as an additional encouragement to those who may be tempted to embark upon the industry of lobster culture, since the lobster being a sedentary or home-staying type, those who sow the pasture lands of the sea with this particular crop may likewise from the same ground reasonably hope in the process of time to reap the fruit of their labours.

If the scheme here proposed of rearing both the eggs and

young of the lobster should be found capable of practical application, it may be hopefully anticipated that a check will at length be given to that most pernicious practice of utilising the spawn or berry of the lobsters for culinary purposes. Tens or even hundreds of millions of lobster eggs, each egg representing a potential lobster, are thus wastefully consumed in this country year after year. The late Mr. Frank Buckland, who was one of the most strenuous protesters against this wanton destruction of lobster spawn, thus writes, in the year 1875, in his "Report upon the Fisheries of Norfolk"—"It must be evident that the destruction of so many lobsters in the form of eggs must of necessity greatly tend towards producing the scarcity of lobsters which is now being felt in the London and other markets." As an illustration of the quantity of lobster eggs that are used by the cooks who must and will have it for colouring fish sauces and for decorative purposes, it will be found stated in the same Report that—no less than from 14 to 18 lbs. of lobster spawn have been supplied by a single collector in this manner for culinary purposes during the two months of April and May. The number of eggs contained in this mass of spawn amounted at the very least, in Mr. Buckland's estimate, to 1,720,320, and this figure represents, it must be borne in mind, but an unimportant fraction of the sum total that is consumed for a like purpose throughout the realms of the United Kingdom. Now, what would be thought of the individual who advocated or carried into practice the utilisation of the eggs of the salmon for a similar purpose*: would any term of opprobrium that might be levelled against him be considered too

* I am informed, on good authority, that salmon spawn, cooked and eaten after the manner of green peas, is not an altogether unknown delicacy in certain parts of Ireland.

strong or any punishment too severe? And yet, precisely such a disastrous policy is in the case of the lobster freely sanctioned and approved, without let or hindrance, every day in the year. A remedy for this long-acknowledged evil has been suggested on many sides in the form of the proposition that the sale of berried lobsters should be made illegal. Such a suggestion, however, if carried into practice, could be easily evaded by the fishermen, who would simply remove and throw away the spawn before bringing the animals to shore. If, however, the cultivation of lobsters from the egg should be developed as a practical industry, there is every reason to believe that a stop would be speedily put to the wholesale destruction of their eggs that is now being carried forward. If the expression of public opinion should prove insufficient to bring about so desirable a result, the supply of eggs at present only flowing to the saucepans of the cooks might be diverted to the hatcheries of the cultivators through the offer, if need be, of a better price than they are at present commanding as a mere condiment for sauce. As a matter of fact, it is simply for its decorative effect and not as a flavouring agent that the article is in such demand by our West End *chefs*, and surely in these days of discovery and invention the chemists might come to our aid with some harmless and yet equally brilliant pigmentary substance, that being utilised as a substitute would remove all further necessity for the present lamentable destruction of embryo lobsters.

The question that remains to be considered is as to whether lobster culture in the manner here suggested might be prosecuted with pecuniary advantage by private individuals, or whether it is a subject adapted only for the intervention of the State. It is certainly scarcely to be anticipated that

many private persons will be found sufficiently philanthropic to undertake the restocking of our exhausted lobster grounds for the benefit of the fishing commonwealth. Nevertheless, there are many large landowners with estates bordered by a rocky coast-line, who would doubtless welcome the opportunity of thus placing at their tenants' disposal the means of materially augmenting their source of income. To those among this category who have had practical experience in trout and salmon hatching, this subject of lobster culture might be especially recommended upon several grounds. The routine in either case will be very similar, while a large portion of the apparatus constructed for salmon hatching might be utilised for lobster culture, and moreover would be empty and available for use just at the time when the lobsters commence to spawn.* To other nations besides our own it may be anticipated that this proposed plan of hatching and rearing lobsters would be found advantageous. By way of illustration, reference may be made to the arduous efforts that were instituted in the United States, and notably by Mr. Livingstone Stone, to transport the lobster across the continent from the Atlantic to the Pacific seaboard where it was previously unknown. Experiments in every instance were made with adult

* Mr. Frank Gosden, pisciculturist to the Duke of Wellington, has imparted to me within the last few days a very interesting piece of information that bears upon the subject of lobster culture. He tells me that for some time past, during the summer months, he has with great success devoted the troughs utilised in winter and spring for hatching trout, to the rearing of newly-hatched freshwater crayfish. Lobster rearing on the same principle he considers would be equally feasible. It is perhaps desirable to mention here that the river crayfish has not, like the lobster, a free-swimming or Zoea phase, but enters upon the ambulatory condition immediately it leaves the egg. The treatment required for the two animals would therefore not be precisely parallel.

lobsters, involving the employment of bulky apparatus, great expense, and many failures before even a small amount of success was obtained.* If, in place of this, recourse had been had to young fry that had arrived at the ambulatory state, and were just ready to transfer to the sea, thousands might have been successfully transported in less space and at less cost. Better results still would, probably, have been arrived at if the eggs only, detached from the females, had been carried across to the Pacific coast, and a hatchery for their development and the rearing of the fry been established contiguous to the shore on which it was proposed to set them free.

Although practical attention has not hitherto been directed to the artificial culture of lobsters from the egg on the system here advocated, experiments have been made both in this country and in France and Norway to establish parks and enclosures for the cultivation or storage of the adult animals. In all these cases, however, so far reported, the results obtained have not been encouraging, the outlay required to keep up the supply of food leaving no margin for profits. It is still, nevertheless, an open question whether or not in certain favourable situations where a food supply could be obtained at a minimum cost, the culture of adult lobsters might not be developed into a remunerative financial enterprise. It may be remarked in this connection that fish condemned as unfit for human food is, to the average amount of one ton per day, sent away for destruction

* According to the latest Report, p. 10 of the Descriptive Catalogue of Economic Crustacea, &c., of the United States, in the Great International Fisheries Exhibition, London, 1883, the attempts made to transport lobsters to the Californian coast have been entirely unsuccessful. Such failure may probably be attributed to the small number of individuals that ultimately survived and were distributed at their port of destination.

from the metropolis of London alone. Now the lobster, as is pretty generally known, is particularly partial to stale fish, and when supplied with fresh food in the tanks of an aquarium, is, unless greatly pressed by hunger, in the habit of burying it until it has arrived at an advanced state of decomposition. It is evident that a very small portion of the fish above referred to that is destroyed daily in this metropolis, and which might be had for the cartage, would suffice to feed many thousand lobsters, and might be converted into that highly esteemed crustacean at a considerable profit to the cultivator. The object of this Paper is not, however, to advocate the cultivation of adult lobsters, but expressly that of establishing hatcheries for the development of the ova and young, for the purpose of replenishing or restocking our much exhausted fisheries.

In this direction it may, I think, be predicated that lobster hatching and rearing is hereafter destined to occupy a prominent position in the science of pisciculture, and if conducted with any approach to the perseverance, intelligence, and ingenuity that has been already concentrated upon kindred branches of the fishing industry, cannot fail to achieve an equally signal and complete success.

ADDENDUM.

It has been represented to the Author of this Paper, since the publication of the first edition in August last, that the addition of illustrations of the metamorphoses of the lobster as herein described would be both of scientific interest and of utility to those who may elect to carry out the practical culture of these crustaceans. A plate, herewith appended, has accordingly been prepared from the series of examples grown at Manchester in the year 1875, and which were exhibited at the recent Conference.

The publication of these figures is rendered the more desirable from the circumstance that neither the earlier nor the later of the several developmental phases of the lobster, as originally supposed, are figured and described in the accounts, previously quoted, given by Professor Sars* and Mr. S. J. Smith,† of the European and American varieties respectively. Those intermediate larval conditions that formed the subject of the above-named authorities' observations are represented, in point of fact, by Figures 3, 4, and 5 alone of the accompanying plate. Neither the first condition in which the lobster leaves the egg, as shown at Fig. 1, nor the final one in which the external branchlets of the thoracic limbs have become obliterated, the long antennæ developed, and the little creature in other respects so modified as to resemble the parent as represented by Fig. 5, are included in the accounts here cited. The material upon which the observations concerning the developmental phases of the lobster, made by Professor Sars and S. J. Smith, were based, was derived, moreover, from surface skimmings in the open sea, or from store ponds in which adult lobsters were kept, and not from examples cultivated by hand through every successive stage, as was the case with those here figured.

As shown in the accompanying plate, no less than five distinct phases intervene after leaving the egg, before the little crustacean becomes recognizable as a veritable lobster. In the first of these (Fig. 1), which is of but very brief duration, the limbs and tail are applied close to the body. The beak or rostrum, which forms so conspicuous a feature in all the succeeding phases, appears at first sight to be altogether wanting, but is found, on closer examination, to be present underneath the transparent outer membrane, but tucked away out of sight between the legs, after the manner of the proboscis in the pupa of a butterfly. This primary larval, or "Zoea" phase, not noticed by Sars or

* *Om Hummerens postembryonale Udvikling.* Af G. O. Sars, Forhandlinger i Videnskabs-Selskabet i Christianana aar 1874.

† 'The Metamorphoses of the Lobster and other Crustacea.' By S. J. Smith, U.S. Fish Commission Report, 1871-72.

Smith, was first observed by Couch so long since as the year 1843, a figure of the same then given by him being reproduced at page lvii of the introduction to Bell's 'History of the Stalk-Eyed Crustacea,' Ed. 1853. The second and third larval conditions (Figs. 2 and 3) very closely resemble one another, and differ most remarkably from the preceding one in the conspicuous development of the beak or rostrum, and of the filamentous natatory appendages, or exopodites of the thoracic limbs. Between themselves these second and third larval conditions are distinguishable by their difference in size, and by the greater numerical development, in the later phase, of spinous processes upon the dorsal aspect of the abdominal segments. In the fourth phase (Fig. 4) rudimentary abdominal appendages have begun to make their appearance. These become more fully developed in the succeeding phase (Fig. 5) where they share with the thoracic appendages, which are now relatively reduced in size, the locomotive function. The corresponding structures developed upon the sixth abdominal segment at the same time convert the hitherto simply spatulate tail into a many-jointed structure, identical in all essential points with that of the adult. With the next ecdysis (Fig. 6) the long antennæ make their appearance, the exopodites or swimming appendages of the thoracic limbs have become entirely obliterated, so that the little crustacean is no longer a Schizopod, like the opossum shrimp (*Mysis*), but is in all respects a typical Macrouran, differing only in its more slender proportions from the parent lobster. At this stage of its existence it is, in fact, so lightly constructed that it either walks along the ground or swims in mid-water, after the manner of a prawn, which it much resembles, and it is only with the next shell-casting or ecdysis about a week later, that the limbs and body, becoming relatively heavier, the normal ambulatory mode of existence characteristic of the adult animal is permanently adopted.

Explanation of Plate.

Illustrating Developmental Phases of the Common Lobster

(Homarus vulgaris).

All the figures, excepting 7 and 8, are magnified representations, the straight or curved lines, drawn in close proximity to the respective figures indicating the natural size of the objects delineated.

Fig. 1. First larval or "Zoea" phase, immediately after exclusion from the egg.

" 2 and 3. Second and third "Zoea" phases devoid of abdominal appendages or swimmarets.

" 4 and 5. Fourth and fifth "Zoea" phases, in which the abdominal appendages are more or less conspicuously developed.

" 6. Sixth phase, in which the adult form is attained through the development of the long antennæ, and through the obliteration of the swimming appendages of the thoracic limbs.

" 7 and 8. A single matured or "eyed" ovum, and a group of similar ova, with their filamentous footstalks, of the natural size.

" 9. One such ovum highly magnified, and showing the enclosed embryo.

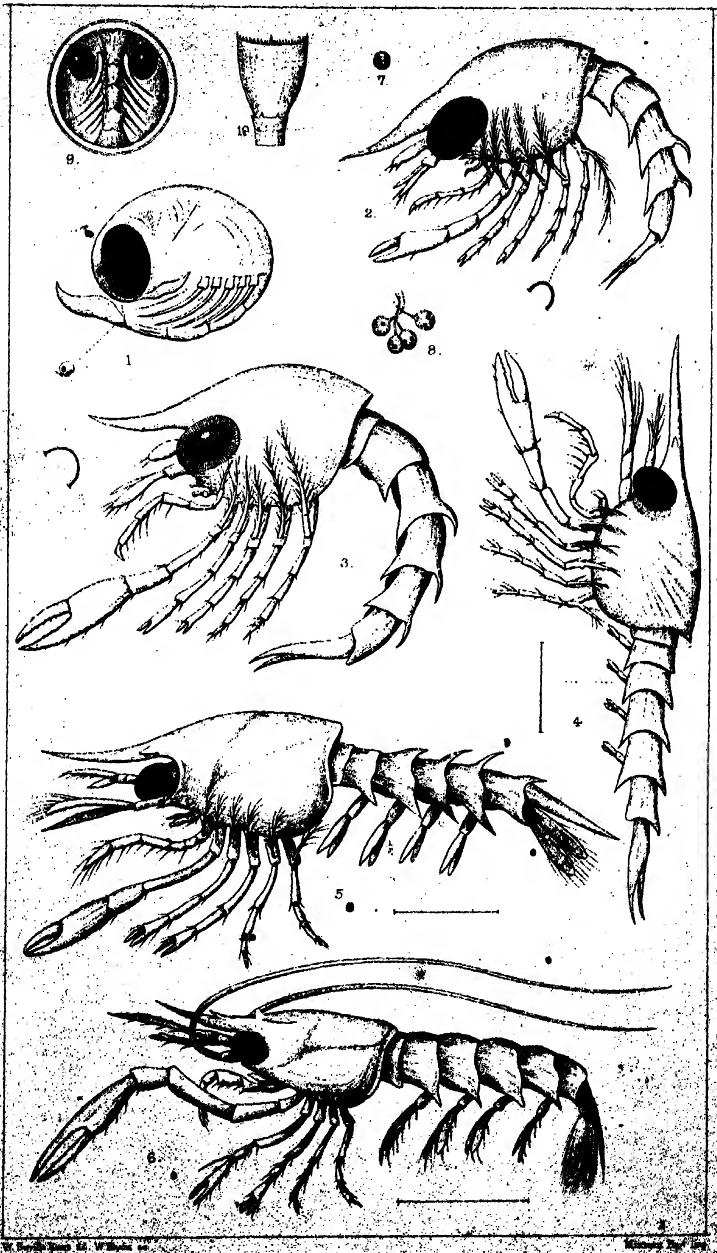
" 10. The simple spatulate form of the tail, as developed in the larval conditions represented by Figs. 1–4.

DISCUSSION.*

Mr. Kenneth Cornish, after some remarks on the value of fish as food, having particular reference to a paper read by Sir Henry Thompson at a previous Conference, was going on to describe an improved method which he

* The following discussion and motions carried refer in part to a Paper that was read the same afternoon by Mr. T. Cornish, on the subject of Crustacea generally.

METAMORPHOSES OF THE LOBSTER (HOMARUS)



had adopted for cooking fish, when he was reminded by the Chairman that the special subject of the Conference that day was crustaceans. He said he would not detain the meeting, but had also devised a method for preserving fish in the form of powder, by which the whole of the nutritive constituents were preserved, including the albumen.

Mr. BIRKBECK, M.P., then moved a vote of thanks to Mr. Cornish and to Mr. Saville Kent for their interesting papers, which had contained a deal of information which was probably new to many persons present. Mr. Cornish had told them of a remarkable fishing ground on the coast of Cornwall, which might be safely fished without any restrictions, whilst on the other hand Mr. Saville Kent had given statistics proving that the supply of lobsters was apparently decreasing rapidly. He might say that on the coast of Norfolk there was a small lobster and crab fishery on a ground of about fourteen miles in length by three to four miles in breadth, which many years ago was a very productive fishery, but unfortunately the practice of breaking up small crabs for bait, and also the practice of sending to market berried hen lobsters, was carried on to such an extent that the fishery was reduced really to nothing. He was asked to institute a Board of Trade inquiry, and the late Mr. Buckland and Mr. Spencer Walpole came down and held it; the result being that an order was passed putting a stop to the capture of berried hen lobsters and also the soft crabs, and the fishermen were strongly advised to stop the breaking up of small crabs for bait. That order was in force for three years, and when it expired, which was on the 1st of February this year, another inquiry was

held by the Board of Trade, under the supervision of Professor Huxley. The evidence which was given, not only from the fishermen, but the salesmen, was so convincing as to the effect of the order being to increase the supply to four or five times what it was previous to the order being passed, that the Board of Trade had now passed an order putting a stop to the practices which were in vogue for ten years, and the fishermen had made up their minds that they would endeavour to get a local Act passed to put a stop entirely to the breaking up of small crabs. That showed what could be done in a small district, and he hoped it would be carried out throughout the country.

Mr. BRADY had much pleasure in seconding the resolution. He did not know that there was any question more interesting than that of crab and lobster fisheries, unless it was the artificial cultivation and production of salmon and trout. He quite agreed with Mr. Saville Kent on the great importance which would be derived from the artificial cultivation of these fish in the same way as salmon and trout, but he did not follow him so far as to think that the same instruments or conveniences could be used for one as were used for the other, inasmuch as one must be carried on near the sea, and the other far inland. With regard to the crayfish, he agreed with him it could be done, but that was only a matter of detail. He feared, however, it would be like other matters which were for the public good, that it would be hopeless to expect private individuals to undertake it. This subject, along with the artificial propagation of the better species of fish, and, probably, eventually they might come to that, was a matter which concerned the S[illegible]

than private individuals, and he thought it would be found very difficult to find private gentlemen so scientific as to go to the very large expense which would be required, without any certainty of recouping themselves or obtaining interest on the money.

The resolution was carried unanimously.

Mr. CORNISH, in reply, having thanked the meeting, said he would make one remark on Mr. Saville Kent's paper, that was with regard to the use of the berry of the lobster. If they could only bring it home to the minds of cooks that the berry of the lobster was absolutely tasteless, and if it had any taste at all it was a slightly unpleasant taste of iron, and that, therefore, it was only valuable as a colouring matter, there might be some hope of putting a stop to the present practice of using it for sauce. He then proposed a vote of thanks to the Chairman for his kindness in taking the chair. He had known him for some years as a practical fisherman, and he was sure a better chairman could not have been selected.

Mr. SAVILLE KENT seconded the motion, which was carried unanimously.

The CHAIRMAN said he could assure the Conference it had given him great pleasure to be present that day, because this question of crustaceans was one which must interest every one. The lobster and crab fisheries had always had a peculiar interest to him, because it was essentially a fishery for poor men. The crabbers generally worked with their own hands alone, and in their own little boats, and were exposed to almost as hard work as any toiler of the sea, so that anything which could

be done to protect their interests, or increase the supply of this fish, would be most valuable to the fishing community. With regard to what had been said about legal interference, he might say that in 1877 an Act of Parliament was passed to a certain extent protecting crabs and lobsters, by prohibiting the sale of undersized fish. The question of berried hens, as they were called, was very much discussed when that Act was passed, and he took a great deal of trouble to get information and evidence with regard to them. It was not the cooks alone who were to blame in causing berried hens to be sent so largely into the market, the fishermen themselves doing it; because the lobsters having berries on them were in as good condition for eating as at any time in the year, and if the sale of berried hens were prohibited, as Mr. Saville Kent remarked, and as he had heard from the fishermen themselves, they would simply evade the law by brushing off the berries. The size of crabs was another question which was very largely discussed, and, as Mr. Birkbeck could bear him out, the people in Norfolk, where crabs were not as large as on the south and west coasts, were in favour of a larger size being named than that which was placed in the Act, viz., 4¼ in. across the crab's back. That was such a tiny thing, and contained so little meat, that a very small extension in the size would produce much more valuable food for the table, and the fish would increase its species in an enormously large proportion. With regard to the district which Mr. Cornish had spoken of, where fishing could be carried on for over 200 square miles without doing any harm, he would point out that there was a great natural protection existing there, for that fishing ground was

exposed to all the tremendous rollers of the Atlantic Ocean, so that it could not be fished so constantly and incessantly as inshore crab fisheries, and those places around the shore where it was acknowledged on all hands that crab and lobster fisheries required protection.

CRUSTACEANS

BY

THOMAS CORNISH.

CONTENTS.

CONFERENCE ON MONDAY, JULY 23, 1883.

MR. JOHN TREMAYNE in the Chair.

CRUSTACEANS.

I HAVE been requested to read to you a short Paper on "Crustaceans."

The Crustaceans are a large class of articulated animals whose distinguishing feature to the mere outside observer is that they are covered over the whole of their bodies and legs by a shell of more or less hardness, and it is this total covering in a coat of mail which mainly sets them apart from other classes of animals.

They are found on the land, in the fresh water, and in the salt water: and, amongst themselves, are divided into two distinct varieties, ie., the "Sessile-eyed" crustacean, in which the eye lies flat in its socket, with just the amount of mobility and scope of vision which the eyes of most animals have; and the "stalk-eyed" crustaceans, in which the animal has a certain limited power of projecting its eye, at its own will, beyond its socket or immediate surroundings, and so obtaining a considerably enlarged sphere of vision.

With the single exception of the common river crayfish I shall confine myself to-day to the crustaceans whose home is in the sea.

Among these I shall very curtly dismiss the "Sessile-

eyed" class, with the remark that no one of them has any interest for us except from a scientific point of view. Practically, so far as they affect us at all, they are objectionable. To them belong the "Hoppers" which make our beaches, and especially those on which sea-weed is apt to accumulate, unbearable on a hot summer's day, and as well that curse of the fisherman who uses trammel nets, one of the gammaridæ which, in countless numbers, will clean to the bone, within eight hours, a fish caught in the net, and send it up as white and neat as ever the Royal College of Surgeons set up a skeleton.

I think I may say that so far as the word "crustacean" conveys any definite idea to the minds of the majority of those here it carries the meaning of "crabs and lobsters;" and I take these animals, which are not unimportant as sources of food supply, with the addition of prawns and shrimps, and their congeners, as the subject of my present paper.

If you will look at the next lobster, or crab, or shrimp, which you may see, you will, with the delicate use of a fork in the case of a boiled specimen, find that it has, or had, an eye placed at the top of a stalk, or pedestal, based within the socket of the eye on a moveable mechanical joint, and there receiving the usual information from the brain of the creature through the nerves. You will find that the socket of this eye is invariably protected by spines of a strength proportionate to the size of the creature, and that this eye can be projected or retracted at the will of the shell fish. It resembles in some respects the telescopic eye of the snail, but it is not capable of anything like the same protrusion nor is it so mobile. In the "shrimps" the eye at its full protusion and elevation rises above the level back of the animal to an extent which enables it to see all round it.

Any one who has watched a shrimp in a small pool of salt water will acknowledge this. Most shrimps are so semi-transparent in water that it requires a practised eye to observe them, but, once see a shrimp leisurely making its way across a pool, thinking of nothing at all, and alarm that shrimp by putting your walking stick in front of it, and you will at once (but to see this you must have learned to watch nature closely) see it raise its little black eyes, take a rapid view of the ground in its rear, and with one flip of its tail disappear stern foremost into the hole it has selected for its place of refuge.

The arched back of the crabs and lobsters prevent the same thing occurring in their cases, but they yet derive a very greatly increased scope of vision from their power of thus protruding their eyes. Quite recently a specimen of a little lobster-like creature, *Scyllarus arctus* (it is so rare in English waters, except in Mount's Bay, that it has no English name) has come into my possession which I have preserved and have with me. It is worthy of notice, not only because its eye is an exceedingly good example of the "stalk-eye," but because I believe only three specimens (two off Plymouth and one from the stomach of a cod taken off Polperro) have been seen in England out of Mount's Bay. In that bay I have secured some twenty specimens, many alive and full of spawn ready to be shed, as was the case with the specimen I have with me. There is reason to believe that it was observed in Mount's Bay so long ago as the middle of the last century; but it is distinctly a crustacean of the Mediterranean Sea.

Confining myself now to these stalk-eyed crustaceans of the sea, I may say that something over one-hundred species have been recorded as having been observed in British waters. A large proportion of these, perhaps one half, are

of the small shrimp and prawn order, which are not carefully looked after, except by naturalists making the study of them their speciality. Of the others (to which I have given much practical attention) I have captured in Mount's Bay with my own hands certainly four fifths of the species known to exist, including many of the rarest specimens occurring in our seas.

I may explain that the reason why I have seen so many species of crustaceans more than my neighbours is that I have fished for them myself. Most of the sea crustaceans are small and considered valueless. This is a misapprehension, nearly all of them yielding dainty food; but the fisherman is intensely conservative in his instincts, and it is a very difficult thing to get him to preserve a crab or a lobster or any of the class which has not already established itself as an edible and saleable commodity. To begin with, they are all his natural enemies. Unless they are caught in the legitimate crab-pot, from which all small specimens can escape, they are taken in his nets. They come into the net in pursuit of the best fish caught in it, and they get entangled. So long as they have life they are using their claws to cut the cords of the net, and so it happens that every crustacean does damage to the net which captures it. The fisherman, intent on his better fish, never waits to disentangle a crab of any sort unless it is a valuable one. He simply wrenches off its legs or lays it, in the net, on the gunwale of the boat and smashes it with his hand to deprive it of the power of doing further mischief, and goes on with the hauling of his net. Thus, rare crustaceans are rarely recognised. I have had in the last thirty years constant opportunities of reversing this process, and of carefully picking out of my nets thousands of little crabs which would have been passed without notice by the

ordinary fisherman: and consequently, partly on that account, and partly on account of the situation of Mount's Bay, I have seen more species of marine stalk-eyed crustaceans than most people.

As the typical "stalk-eyed" crustaceans of our British waters you may take the common lobster, the common crab, and the cray-fish (either salt water or fresh water—it does not matter which). You know about the size of these. The largest crab on record weighed something over 13 lbs., and its preserved shell is now in Mr. Laughrim's collection in the Natural History Department of this Exhibition. The largest lobster (the specimen is in the same place) weighed something short of 12 lbs.* The sea cray-fish is, to look at, a larger animal than either the crab or the lobster, but, having no large claws, always turns out of lesser weight size for size.

But what are these puny creatures to the stalk-eyed crustaceans of other days! I do not now refer to the sprawling spider crab exhibited in the Japanese Department of this building, and which measures I believe, ten feet from finger tip to finger tip; but to that huge, solid lobster-like crustacean disclosed to us by geological research, and which must have been some eight feet long in the body, and have contained meat enough to make a salad for a regiment of soldiers!

Still, as we only have these little specimens left, we must do the best we can with them; and the first thing to which I will call your attention is a matter which strikes the observer last of all. You probably know that crustaceans are propagated from eggs which, whilst in the body of the lobster, or cray fish, are found in the form of "coral," but

* There is a specimen of a Lobster in the Fishmarket, I.F.E. which weighed over 20 lbs., but it is from America.

which when further developed appear outside in the form of "berry." In this latter form you also find them in the crab. From these eggs are hatched some wonderful little creatures of intense activity, resembling nothing so much as the animalculæ shown by the microscope in a drop of ditch water. They are as unlike the shellfish they are to become in mature life as a grub is unlike a butterfly, and, curiously enough, they are sessile-eyed.

I will now go on to the lives of the crustaceans after they have assumed their final shape. They all are much of the same size when extruded from the egg; but at maturity they vary from the "common Pea-crab" or from "Andrews's Galathea," either of which at its full maturity can be placed on a threepenny bit and leave an ample margin, up to the largest of our lobsters, crabs, and crayfish. When I was learning these matters the late Professor Bell used very kindly to allow me to send to him for identification any specimens about which I had any doubt, and in 1864 I procured from the submerged part of a deep sea buoy specimens of two very tiny crabs, neither of which was more than ¼ inch across the back. One, I thought, I identified as *Eurynome aspera* a crab so rare that I dared not mention it on merely my own authority. The other I could not make out at all, so I sent both to Professor Bell. To my extreme delight he told me I had *E. aspera* in its young, but final, form, but he took all the pride out of me by pronouncing the second specimen to be a young common crab. I mention this to show how tremendously this latter crab increases in size and bulk.

And as to this question of bulk. The stalk-eyed crustaceans are, as we have considered, enveloped in a hard and non-elastic coat of mail. We have seen that they increase enormously in size. How then do they grow? They grow

in this way: Once in every year, and, of the same species, at the same time in every year, the crab or lobster, or crayfish or shrimp, instinctively retires to some lonely hole in the rocks, and mopes until a crack in the shell occurs across it, precisely where the carapace or back ends, and the tail begins. So soon as this happens the animal begins to drag its whole self out of the shell. In from half an hour to an hour it has drawn the flesh of its great claws out of their shells through the little wrists, and has even drawn its eyes out of their protecting cases or pedestals, and has cleared itself of its old shell altogether, and it lies beside it a perfect crab, or whatever else may be its shape, but quite soft and shell-less, and apparently exhausted. The empty shell also retains its perfect shape; but a comparison of the two shows you at once how the growth takes place. The real crab is sizes larger than its late shell, and in about a week a new shell has hardened over it, and this process is repeated yearly, as I have said, until a period of age comes at which it apparently ceases, and the creature grows no more. We judge this because we find that our very largest specimens are always covered with corallines of very slow growth.

Probably most of you consider of a crab or lobster as you see it on a fishmonger's stall, a squat thing with its legs sprawled out. But they are very different when alive and in the sea. Then those long legs are in their proper position, and the shell-fish walks on them daintily, with its long antennæ or feelers out in constant motion searching for its food. The lobster is a foul feeder, and prefers its food in a state of putridity, or at all events, not fresh; but the crab will touch nothing that is not fresh. Any of you acquainted with the working of aquariums may be able to correct me in this statement; but I make it from my

practical knowledge of the baits we use in fishing for crabs and lobsters. In each case we use fish bait. I once discovered a benighted little fishing cove where the fishermen actually commonly used large turbot and red mullet —a pound and a half and over in weight—for bait for crab. They had no market for turbot and red mullet, whilst they had for their crabs and lobsters. Having, of course, much finer gear with me than they used, I very soon harried the inshore sands, and established a barter market in which one turbot of good size was exchanged for one ray of any size, and a small ray equalled a good red mullet. When ray were scarce with me, the market price of a turbot was 1*s.*, and that of a red mullet 6*d.*

To this question of the bait offered to—which means, of course, the favourite food of—some crabs, I can offer another illustration. The red mullet which we catch are taken in fixed-bottom fishing nets called trammels, and the fish caught in these nets frequently remain for many hours before they are taken out, and we find that crabs, and especially the spider crab—our English representative of the gigantic crab in the Japanese Court, of which I have made mention—always attack the liver, the dainty part of a red mullet, first. Sometimes they eat more of the fish; but the liver invariably suffers first. We know this because from the peculiar formation of the net the attacking crab is almost invariably captured with its prey.

But this fact of the preference of crabs and lobsters for soft bait suggests another question. If the food which they preferentially seek is of this soft nature why should they be furnished with claws of such tremendous cutting and crushing power? Every crab and every lobster is furnished with a claw (the smaller one) adapted for cutting as scissors do, and another, the larger one, adapted for crushing; and

between these two claws they can tear every bit of food they capture into little fragments and feed themselves with it, literally "from hand to mouth." It is a very pretty sight indeed to see the tiny *Galathea Andrewsii*, of which I spoke just now, kept in the holes of a clinker, in a soup plate filled with salt water, come out of their holes when the water is stirred, and feed themselves with particles of food utterly invisible to the unassisted eye, by capturing some passing bit of food in their elegant little claws and conveying it to their mouths, precisely as we should do with a cherry or bit of biscuit. Crustaceans are slow of movement, and may have to feed on things of a much harder nature than the bait with which we fish for them. This may explain the necessity for their having such powerful hands, for their claws are but hands. But then, as they are an exceedingly pugnacious class of beings, it may be that the extraordinary power given to their hands is needed for belligerent purposes. A crab will fight anything. I have seen a captured crab seize a captured picked dog-fish by the tail, and the dog-fish, striking backwards, as is its wont, make its spines "click" (ineffectually of course) on the back of the crab repeatedly; until the crab got a grip with its other claw on the dog-fish's throat, and then the battle was over. Of course a crab, size for size, is much harder and more powerful than a lobster. I have seen a crab, in conflict with a lobster, catch the latter over the forepart of the head, where its shell is hardest, and crush it in by one effort. No lobster could do this to a crab fairly its equal in size. And it rather bears out my idea that the claws of these creatures are weapons of war rather than means of providing themselves with food, that the moment any one of them receives severe injury in a claw it "shoots" it, that is, it deliberately

severs the connection of the claw with the body at the shoulder—the joint next the body—by an act of its own will, and that Nature regularly and repeatedly (but on each occasion with less effect) reproduces the claw on a smaller scale than the one shot off. It seems probable that if the large claw was necessary to the feeding of the animal Nature would rather seek to cure an injury to it than let the animal discard it altogether; but the crab makes no two ways about it. Within a second of the injury received the whole limb is discarded; and lobsters are much more apt to do this than crabs. This known difference in the temper of the two came out once very funnily whilst I was fishing. We value lobster much more than we do crab. A crab, when it catches you, holds on with a crush much harder than does the lobster. An old boatman of mine once, whilst landing a lobster, got caught by it over the thumb. Any violent act of resentment would have made the lobster shoot its claw; and I looked round just in time to see the boatman balancing the lobster up and down from the gunwale of the boat, bearing the pain of the pinch, and apostrophising it with "Ef thee'd a-ben a crab I'd ha' smashed thee agen the gunnel."

But, having dealt with the food of crustaceans, we will deal with the crustaceans as food. Many of the smaller species—all, in fact—are utilised as food by fish of several species (families, I may say). Thus the family of the cod (*Gadidæ*), and of the flat-fish (*Pleuronectidæ*), feed largely on stalk-eyed crustaceans, and so, indirectly, make them available to us as food. So well is this fact known amongst those interested in the subject that no one of them would permit the stomach of a cod or a dorse, and some other allied species, to be thrown away without a careful overhauling first. The first recorded specimen of the rare

crustacean, *Scyllarus arctus*, to which I have alluded was found by my friend the late Mr. Jonathan Couch in the stomach of a cod. The only specimen I ever saw of a crab called the long-legged portunus (*P. longipes*) I obtained from the stomach of a dorse. But specimens thus obtained are of course not available to us as food. We have recognised the value of the larger species, and passed no end of laws to protect them in their earlier stages. For about three families we have made close times and size-rules, and all the rest of it. I do not know but that in some districts these things may be beneficial, but I do know that the Commissioners who inquired into the matter found that there existed off the Land's End one solid bed of crab and lobster deep-sea fishing ground of at least 200 square miles in extent; and they thought, and I think with them, that it will take a good many centuries to exhaust that field by any method of fishing. The crustaceans of that district and the coal of England will be exhausted much about the same time. I am not aware that any fishing ground approaching this in extent exists elsewhere in Great Britain, and I approve of the legislation which has taken place. Where the area of production, and therefore the area of fishing, is limited, protection is absolutely necessary if the efficiency of that particular fishery is to be maintained. By actual experiment I have ascertained that a common edible crab (*Cancer pagurus*) measuring three inches across the carapace, or back, turns out one ounce and a half of meat available for food, whilst a crab of four inches across the carapace (a size which a three-inch crab would probably attain in its next year of growth) turns out four and a half ounces of meat available for food. Clearly therefore the young crab should be protected, but the enforcement of protection by law is very difficult. It

might be otherwise if the men who fish limited areas could be made to understand that in the long run close protection will prove their best friend.

We are eating these large crustaceans as luxuries, and we are eating shrimps and prawns as dainties; but between these two there exist several species of crustaceans which attain maturity at a size of from three to five inches across the back which we never think of eating, but which yet are full of excellent meat. We make a delicacy of the river crayfish, but we despise, or rather utterly ignore, the spider crab, the shore crab, the two larger *Xanthos*, the velvet swimming crab, the *Galatheas* (squat lobsters) and many others—including the one, *Scyllarus arctus*, which I have mentioned, but which must, in the present state of our knowledge about it, be treated as of very local permanent occurrence in our seas; other observers than myself, placed by my experience on the scent, may establish it as a common inhabitant of our waters. Of all of those, untold stores might be captured along all our rocky sea-shores, and all of them yield good food in larger quantities, and with not much more trouble, than would an average prawn. We do not trouble about them, and their capture is, as I have shown, a chance affair; but go to the Japanese Department, or the Chinese, or even to our own Department of Speculative Ideas in this building, and see what endless pots and models of pots and traps there are exhibited there, designed on purpose to catch prawns and shrimps, but which would also catch these wasted treasures of the sea, if they were looked after.

This waste of food supply is due to two causes—one is that the "men that know" (the scientific naturalists) take no measures to reduce their knowledge into practice. And the other is that the "men that work" (the fishermen) are

naturally, as I have said, unwilling to save sea produce which is worse than useless to them without a market. This remark applies equally to enormous quantities of fish which are captured constantly in ordinary trawling, and, because they are strangers to the fishermen and will not find a market, are thrown overboard as useless. It is not quite germane to my subject, but if it were I could dilate on scores of species of fish constantly taken in our seas, excellent as food, and thrown overboard simply because, being unknown, they would find no sale. If this Exhibition can, as one only result, break down the arrangements which keep good and cheap, but comparatively rare, fish out of the public markets, and so cause the demand which can and will create a supply, it will have conferred a very great boon on the English public; and I do not see why it should not do it. I have never yet seen a fish that is unfit for food, if in good condition at the time of its capture; and in saying this, I am saying much, for I have made it a rule to have cooked the second specimen of any rare fish which I get. The first is of course set up for some museum.

There is another thing about our smaller crustaceans which is worthy of notice. Some of our little crabs—and I dare say more in other species than I have noticed—give us notice in spring of the fish which we may expect in autumn. For instance the occurrence in free numbers in April of a small crab known as the "masked" or "old man" crab (*Corystes cassivelaunus*) in particular localities always assures us that about August we shall in the same locality get an abundance of plaice, and soon after that large red mullet. When I say large red mullet I speak of fish weighing from 42 oz. (the heaviest ever recorded in British seas, and taken in Mounts Bay) to 25 oz., and thence to 16 oz. At this time these facts are to us coincidences,

and nothing more; but if they were closely followed up by many observers, they would produce for us more good fish than we get on our present haphazard principles.

I spoke just now of the very combative nature of some of the stalk-eyed crustaceans. The species that most excel in this quality are the soldier or hermit crabs. Their first idea of independent life is to eat some friendly whelk, and occupy its shell. Their next is to give battle to every crab of the same persuasion as themselves that they come across; and altogether they form, as you can see in any aquarium, the most quarrelsome and most amusing set of crustaceans in existence.

It may seem utterly absurd to speak of these hard-shelled crustaceans as capable of suffering from skin-disease, but it is nevertheless the fact that they are so. Under certain circumstances, of which we know nothing, a peculiar cancerous eating out of the outer part of the back and claws takes place, spreading irregularly like a map over the crustacean, and showing a black colour. Shell-fish thus attacked are known as "pocked" crabs or lobsters, and are unfit for food; but I need not labour this point further, because I know of no fisherman who would send a crab of this sort into the market.

One more statement of a fact (some people might call it an anecdote) and I have done. Most of you probably know that on a dark summer's night the water of the sea, to the depth of as much as twenty fathoms, is from some cause or another luminous when disturbed. When this phenomenon occurs, a fishing line can be traced down its whole length, and a fish caught at the bottom of the sea comes struggling and sprawling up in a blaze of phosphorescent light. I was once fishing in about fourteen fathoms of water, when I hooked a fish. I hauled it up, making as it came a most pro-

digious luminosity. When it came alongside, my boatman struck at it with the gaff, and off from amidst the mass of phosphorescent light the iron gaff came with a click. He struck again with the same result. And he said, "This thing is not right, master; let it go." I did not. I gave a dead haul, and got aboard a very large sprawling cray-fish. It was not, as my boatman had supposed, a direct emanation from the regions below.

DISCUSSION.*

Mr. KENNETH CORNISH, after some remarks on the value of fish as food, having particular reference to a paper read by Sir Henry Thompson at a previous Conference, was going on to describe an improved method which he had adopted for cooking food, when he was reminded by the Chairman that the special subject of the Conference that day was crustaceans. He said he would not detain the meeting, but had also devised a method for preserving fish in the form of powder, by which the whole of the nutritive constituents were preserved, including the albumen.

Mr. BIRKBECK, M.P., then moved a vote of thanks to Mr. Cornish and to Mr. Saville Kent for their interesting Papers, which had contained a deal of information which was probably new to many persons present. Mr. Cornish had told them of a remarkable fishing ground on the coast of Cornwall, which might be safely fished without any restrictions, whilst on the other hand Mr. Saville Kent had given statistics proving that the supply

* The following discussion and motions carried, refer in part to a Paper that was read the same afternoon by Mr. W. Saville Kent, on the subject of "Artificial Culture of Lobsters."

of lobsters was apparently decreasing rapidly. He might say that on the coast of Norfolk there was a small lobster and crab fishery on a ground of about fourteen miles in length by three to four miles in breadth, which many years ago was a very productive fishery, but unfortunately the practice of breaking up small crabs for bait, and also the practice of sending to market berried hen lobsters, was carried on to such an extent that the fishery was reduced really to nothing. He was asked to institute a Board of Trade inquiry, and the late Mr. Buckland and Mr. Spencer Walpole came down and held it; the result being that an order was passing putting a stop to the capture of berried hen lobsters and also the soft crabs, and the fishermen were strongly advised to stop the breaking up of small crabs for bait. That order was in force for three years, and when it expired, which was on the 1st of February this year, another inquiry was held by the Board of Trade, under the supervision of Professor Huxley. The evidence which was given, not only from the fishermen, but the salesmen, was so convincing as to the effect of the order being to increase the supply to four or five times what it was previous to the order being passed, that the Board of Trade had now passed an order putting a stop to the practices which were in vogue for ten years, and the fishermen had made up their minds that they would endeavour to get a local Act passed to put a stop entirely to the breaking up of small crabs. That showed what could be done in a small district, and he hoped it would be carried out throughout the country.

Mr. Brady had much pleasure in seconding the resolution. He did not know that there was any question more interesting than that of crab and lobster fisheries,

unless it was the artificial cultivation and production of salmon and trout. He quite agreed with Mr. Saville Kent on the great importance which would be derived from the artificial cultivation of these fish in the same way as salmon and trout, but he did not follow him so far as to think that the same instruments or conveniences could be used for one as were used for the other, inasmuch as one must be carried on near the sea, and the other far inland. With regard to the cray fish, he agreed with him it could be done, but that was only a matter of detail. He feared, however, it would be like other matters which were for the public good, that it would be hopeless to expect private individuals to undertake it. This subject, along with the artificial propagation of the better species of fish, and probably, eventually they might come to that, was a matter which concerned the State more than private individuals, and he thought it would be found very difficult to find private gentlemen so scientific as to go to the very large expense which would be required, without any certainty of recouping themselves or obtaining interest on the money.

The resolution was carried unanimously.

Mr. CORNISH, in reply, having thanked the meeting, said he would make one remark on Mr. Saville Kent's paper, that was with regard to the use of the berry of the lobster. If they could only bring it home to the minds of cooks that the berry of the lobster was absolutely tasteless, or if it had any taste at all it was a slightly unpleasant taste of iodine, and that, therefore, it was only valuable as a colouring matter, there might be some hope of putting a stop to the present practice of using it for sauce. He then proposed a vote of thanks to the Chairman for his kindness in taking the chair. He had

known him for some years as a practical fisherman, and he was sure a better chairman could not have been selected.

Mr. SAVILLE KENT seconded the motion, which was carried unanimously.

The CHAIRMAN said he could assure the Conference it had given him great pleasure to be present that day, because this question of crustaceans was one which must interest every one. The lobster and crab fisheries had always had a peculiar interest to him, because it was essentially a fishery for poor men. The crabbers generally worked with their own hands almost, and in their own little boats, and were exposed to almost as hard work as any toiler of the sea, so that anything which could be done to protect their interests, or increase the supply of this fish, would be most valuable to the fishing community. With regard to what had been said about legal interference, he might say that in 1877 an Act of Parliament was passed to a certain extent protecting crabs and lobsters, by prohibiting the sale of undersized fish. The question of berried hens, as they were called, was very much discussed when that Act was passed, and he took a great deal of trouble to get information and evidence with regard to them. It was not the cooks alone who were to blame in causing berried hens to be sent so largely into the market, the fishermen themselves doing it, because the lobsters having berries on them were in as good condition for eating as at any time in the year, and if the sale of berried hens were to be prohibited, as Mr. Kent remarked, and as he had heard from the fishermen themselves, they would simply evade the law by brushing off the berries. The size of crabs was another question which was very largely discussed, and, as Mr. Birkbeck could bear him out, the people

in Norfolk, where crabs were not as large as on the south and west coasts, were in favour of a larger size being named than that which was placed in the Act, viz., 4¼ in. across the crab's back. That was such a tiny thing, and contained so little meat, that a very small extension in the size would produce much more valuable food for the table, and the fish would increase its species in an enormously large proportion. With regard to the district which Mr. Cornish had spoken of, where fishing could be carried on for over 200 square miles without doing any harm, he would point out that there was a great natural protection existing there, for that fishing ground was exposed to all the tremendous rollers of the Atlantic Ocean, so that it could not be fished so constantly and incessantly as inshore crab fisheries, and those places around the shore where it was acknowledged on all hands that crab and lobster fisheries required protection.

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